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# NASA Ames Summer High School Apprenticeship Research Program

JUNE 16-AUGUST 15, 1986

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# **NASA Ames Summer High School Apprenticeship Research Program**

## **June 16-August 15, 1986**

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STUDENT PAPERS - Coordinated by Patricia Powell  
Ames Research Center, Moffett Field, California

September 1988

**NASA**  
National Aeronautics and  
Space Administration

**Ames Research Center**  
Moffett Field, California 94035

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## INTRODUCTION

Engineering enrollments are rising in universities; however, the graduate engineer shortage continues. Particularly, women and minorities will be underrepresented for years to come. As one means of solving this shortage, Federal agencies facing future scientific and technological challenges were asked to participate in the Summer High School Apprenticeship Research Program (SHARP). This program was created seven years ago to provide an engineering experience for gifted female and minority high school students at an age when they could still make career and education decisions.

The SHARP Program is designed for high school juniors (women and minorities) who are U.S. citizens, are 16 years old, and who have unusually high promise in mathematics and science through outstanding academic performance in high school. Students who are accepted into this summer program will learn as they learn by working 8 hours a day in a 5-day work week. This work-study program features weekly field trips, lectures and written reports, and job experience related to the students' career interests.

The experience of SHARP '86 will be long remembered by the fortunate high school students who worked with the team of mentors from many different branches here at Ames Research Center. Some of the spirit of excitement and challenge of the students and the dedication of the scientist-mentors has been captured in this volume and in the following comments from some of the students and mentors.

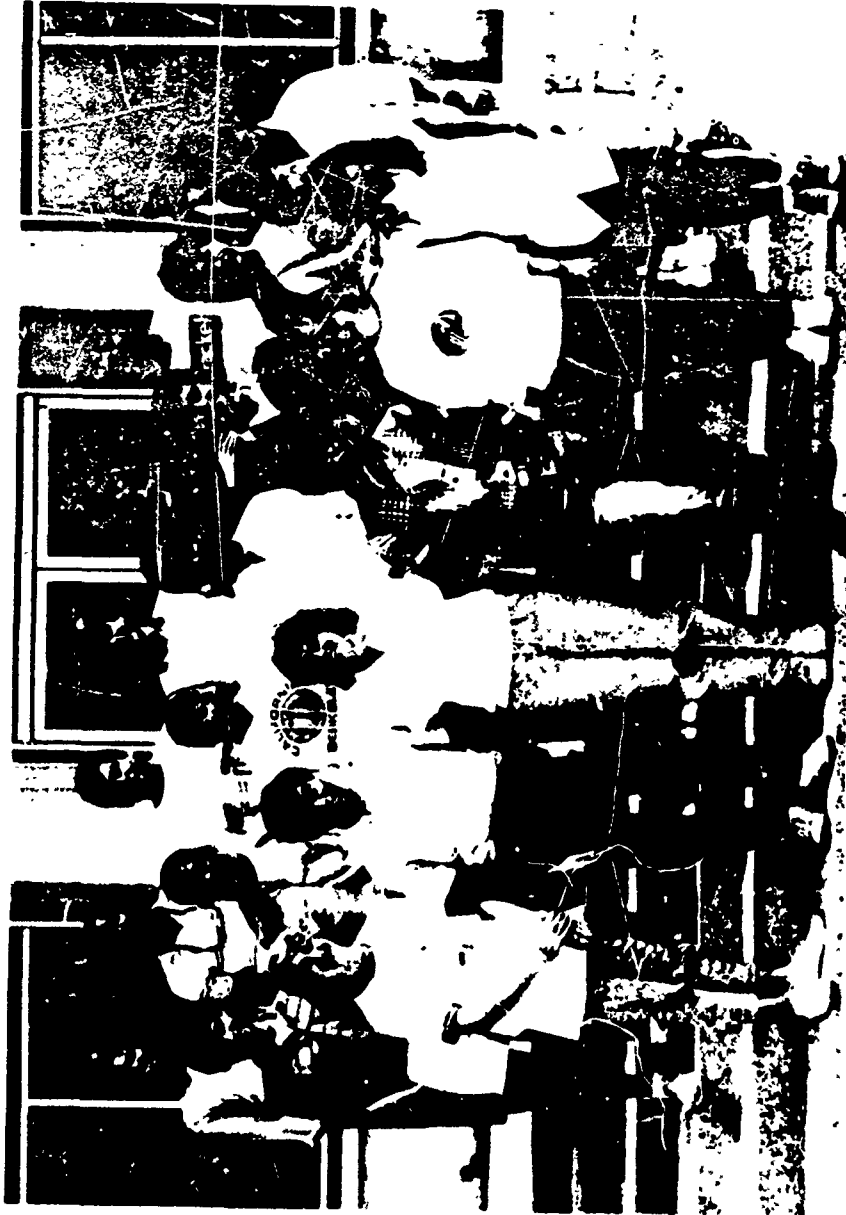
*"It seems to hold a very challenging and promising future for me."*

*"It has enabled me to gain experience and knowledge I could not have acquired from books."*

*"The SHARP program has helped me to plan a science and mathematics-based curriculum in college."*

*"I have been most impressed by the absolute enthusiasm and theoretical know-how that all these students bring with them."*

*"It is a delightful experience each year to have such highly motivated and goal oriented students in our lab."*



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The objective of the Summer High School Apprentice Research Program (SHARP) is to recognize high school juniors who have demonstrated unusually high promise for success in mathematics and science. Nineteen students were accepted to participate in this summer's SHARP. Some special features of SHARP include field trips to private industries and local colleges, special lectures, individual and group counseling sessions, written research papers, oral reports, and the opportunity to be exposed to the present frontiers in space exploration and research.

Top Row: Anthea Charles (Administrative Assistant), Derrick King, Joe Garcia, Sandor Nagy, Bruce Mendez, Todd Hosein, Patricia Powell (Faculty Coordinator).

Middle Row: James Peredo, David Carnes, Jozelle Cox, Edwin Price, Abraham Munoz, Jennifer Nicholls, Katherine Kenning

Bottom Row: Chertanne Carlisle, John Moon, Angela White, Alfredo Martinez, Bonnie Rosenberg, Jennifer Wei

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## **LIVING AND WORKING IN SPACE**

**Linda Armstrong**

We can follow our dreams to distant stars, living and working in space for peaceful economic and scientific gain. Tonight, I am directing NASA to develop a permanently manned Space Station and to do it within a decade.

**President Ronald Reagan  
State of the Union Message  
January 5, 1984**

With these words, President Reagan officially began NASA's most difficult venture yet. NASA had been working on plans for the Space Station for several years before this announcement was made. However, the President's message was of great importance because it clearly told the world that the Space Station was a top priority of the United States government and that NASA would receive the funds necessary to undertake such a huge project.

Johnson Space Center in Houston, Texas, was chosen to lead the development of the Station, though all NASA facilities will be involved in the great amount of research that has to be done. It was estimated that the entire project will cost approximately eight billion dollars. Under the leadership of Phillip Culbertson and John Hodge, the Office of Space Station, at NASA Headquarters in Washington, D.C., has announced the basic plans for the station which is scheduled to be operational by the mid-1990s.

At this time NASA is planning to have a zero gravity environment in the Space Station. Though some scientists still argue that the Station should be rotated to create artificial gravity, there is no real need to create gravity. In fact, the major reason that the Station will be used for scientific work and commercial materials-processing is that it is a microgravity environment. NASA scientists continue to study the effects that living in zero gravity has on the cardiovascular system, body-posture, and spatial orientation to confirm that this environment will not be harmful to the astronauts.

The Station will fly at an altitude of 370 to 580 kilometers in low Earth orbit. This is the upper range of the Space Shuttle's average orbital altitude. The Station will lie in a low-inclination orbit at 28.5 degrees to the Earth's equator. It will be placed at an altitude and inclination which will allow it to avoid meteoroids, space debris, and radiation which are particular dangers for the crew.

The living and working areas of the Space Station will consist of a cluster of similar cylindrical modules each the size of a mobile home. Computerized climate control will keep the interior temperature comfortable, and a normal Earth atmosphere of mixed nitrogen and oxygen will be maintained so that the astronauts will need no special life support gear. Since all parts of the Station will be carried up inside the payload bay of the Space Shuttle, the size of the modules are limited by the

dimensions of the payload compartment. The modules will be approximately 7.3 meters (24 ft) long and 4.25 meters (14 ft) in diameter to fit into the payload bay which has a length of 18.3 meters (60 ft) and a diameter of 4.27 meters (14 ft).

This size is significantly smaller than Skylab which had a diameter of 6.5 meters (21 ft), and was therefore a less confining environment for astronauts. Each Space Station module will have a volume of about 105 cubic meters (3,700 cubic ft). NASA hopes to avoid the serious problems that these dimensional constraints can cause in the decrease of human performance over extended periods of time. This concern becomes more important as crew sizes and mission durations increase. The weight of the initial Space Station will be approximately 36 metric tons. Though the weight will be meaningless in space, it is important in terms of how much the Shuttle will be able to carry in each launch.

Each module will have a certain function. The habitation modules will house the crew and contain individual sleeping compartments, a kitchen and dining area, exercise equipment, and a personal hygiene facility. One laboratory module will focus on the study of life sciences and the other on materials processing. Many companies are eager to rent space in this processing module to experiment with building electronic components and creating crystals and metal alloys in a zero gravity environment.

The logistics module will contain a 90-day supply of food, water, and clothing, and the entire module will be able to be removed and replaced. Each time the Shuttle visits the Station, it will bring a fully loaded logistics module in its payload bay to replace the depleted module. This will be done on the same flights that bring up the replacement crews. Research is still being done to determine if it will be possible to recycle water and to launder clothing in the Station, thus decreasing the need for new supplies. The ultimate goal of this research is to create a bioregenerative life support system in which plants will revitalize the air, process wastes, and grow food for the astronauts.

The end of each module will have a round end cap which can be removed to connect the module with a tunnel called a multiple docking adaptor. An adaptor connects two modules and can also serve as a temporary connection between the Station and the Shuttle, when it docks periodically.

To decide the exact arrangement of the modules NASA officials have met at various conferences in the past years. The original arrangement, called Phase A--CDG-1 (see figure 1), was chosen by the Space Concept Development Group which met from May 1, 1983, to May 1, 1984, in Washington, D.C. This early idea was later changed to a "racetrack" circulation-loop pattern, the Phase B Reference Configuration (see figure 2), by the "Skunkworks" conference at Johnson Space Center from May to July 1984. Debate continues over the final arrangement of the modules.

Instead of having one centralized command module from which all control of the Station would be done, the command and control system will be distributed throughout the modules. In each module there will be a basic command and communications

console from which all major functions of the Space Station can be monitored and controlled. The Station Commander will be able to move freely about the station to perform tasks, but he or she will never be more than twenty feet from a command console.

The Station will not require continual human monitoring, because it will be highly automated. Machines will perform repetitive, boring, and dangerous tasks and will also provide automatic fault detection and recovery. The crew will supervise the machines, handle emergencies, make repairs, and conduct experiments. The Station will basically fly itself, and human intervention will only be needed if an emergency occurs.

In addition to the distributed command consoles, there will be one or two proximity-operations work stations. These window consoles which provide views of space will be used for any functions which require direct visual observation, such as docking with the Shuttle and extravehicular activity (space walking).

Emergency provisions for the Space Station will be distributed throughout the modules so that each module will contain a "safe haven," an emergency supply of food, water, clothing, life support systems, and waste management systems. This standard pack of supplies will be built into each module. The contents of one pack will be able to support the entire Space Station crew of eight for a period of 21 days until rescue by the Shuttle is possible.

In addition to the cluster of pressurized modules, there will be many other parts of the Space Station. The primary source of energy will be photovoltaic arrays of solar cells which total about 2,000 square meters in area. The arrays will be attached to a metal truss structure (see figure 3) and will generate about 75 kilowatts of electrical power, sufficient to meet the initial needs of the Station. They will be programmed to move to face the Sun in order to receive the maximum amount of light. The use of solar power has been chosen over the option of using nuclear power, because of the potential crew danger of having a nuclear reactor on-board the Station. Array panels similar to the solar ones will contain radiators to dissipate excess heat which is generated from Station operations.

Two free-flying platforms will orbit near the Station. One will fly in the same 28.5 degree orbit as the Space Station. It will carry scientific and commercial research experiments which will need only occasional attention from the Station crew. The other platform, flying in a 98 degree Sun-synchronous polar orbit, will be used to observe the Earth. Scientific experiments which depend on stabilized and accurately pointed instruments need to be mounted on these free-flying platforms. The distance protects them from destabilizing forces caused by the movement of the Station.

An unpressurized module connected to the Space Station will serve as a servicing station for satellites. Repair and maintenance of scientific and commercial satellites will be done in this module. Its equipment will include a large mechanical arm which will move structures in and out of the servicing module. The arm will be an advanced version of the Remote Manipulator System developed for the Space Shuttle by Canada.

The crew of the initial Space Station will be six to eight people, but the crew size is expected to increase to twelve to sixteen people by the year 2000. The astronauts will have a wide variety of backgrounds and talents. A typical crew will consist of two pilot-astronauts, two or three mission specialists, and three or four payload specialists who are scientists or researchers from private industries. The crews will train extensively together before their missions, though payload specialists will probably not receive as much training as the other crew members. Part of each crew's training might include working as mission ground controllers for other crews.

NASA has decided upon certain capabilities that the Space Station should have. It should be capable of functioning for 90 days in orbit without a Shuttle visit for resupply or rotation of the crew. In the event of an emergency situation, the crew should be able to live for 21 days in a survival mode using the "safe haven" supplies. This period of 21 days was chosen because 19 days are necessary to put the Shuttle back into orbit to carry out a rescue.

The Station should be able to go for five days without routine ground support, such as instructions and information, from Mission Control. This capability requires that the Station have an extensive database about Station construction, maintenance, and operations. But in the case that vital information is not available in the Station database sometime during this five day period, Mission Control will leave a continuously open channel for the crew for emergency calls. Mission Control will be capable of providing the astronauts with expert consultation by a scientist on the problem within four hours.

There must also be a large data storage base so that the Station will be capable of storing all of the data that it collects over a 24 hour period. This is necessary because NASA officials have specified that the Station must be able to spend one day in orbit with no communication from Mission Control, including sending down data to be stored. A final goal of NASA is to reduce the large staff that will originally be necessary at Mission Control. Eventually, there will only be a small staff working two to five days a week, eight hours a day, providing routine-operations support to the Station. This will lead to a reduction in overall operating costs for the program and will shift much of the decision-making responsibility from the ground crew to the astronauts in orbit.

For the future, NASA is looking at the possibility of adding a second Space Station in a polar orbit to allow for more areas of research to be conducted. The initial Station is expected to last for 20 to 30 years before it will have to be replaced. By that time, further engineering developments will allow NASA to build a new Space Station with incredible new features and capabilities.

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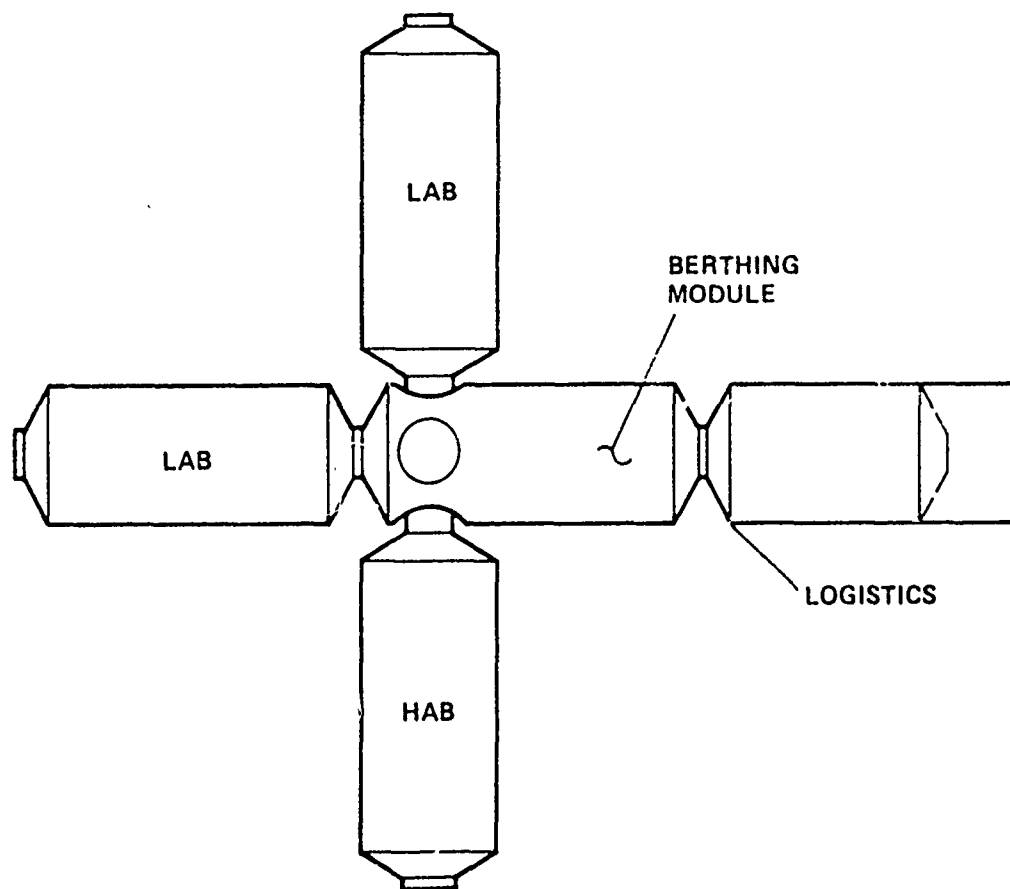


Figure 1.- "Phase A -- CDG-1" Baseline configuration module connection pattern.

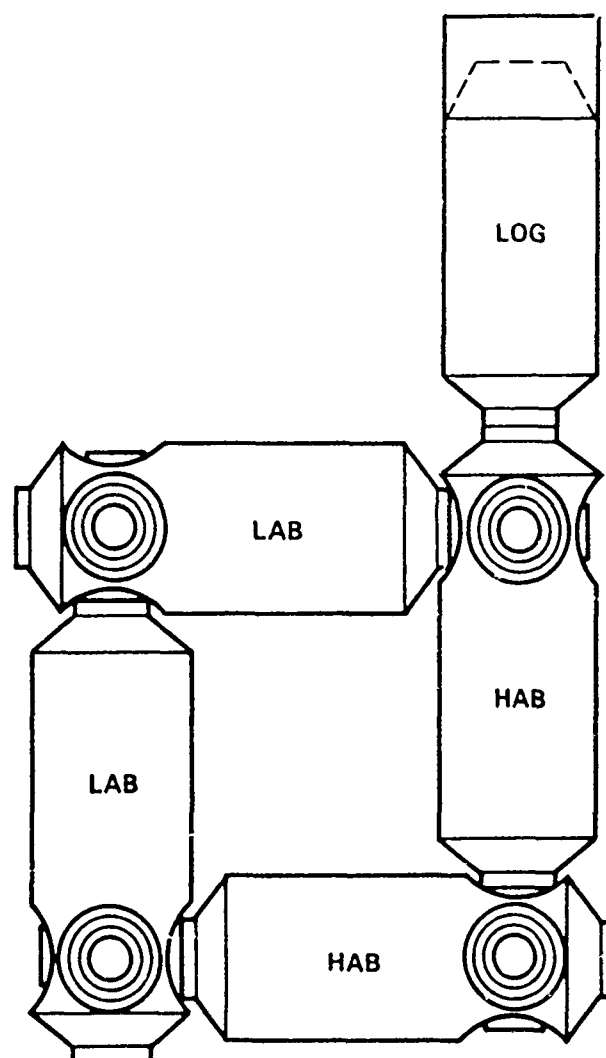


Figure 2.- "Phase B" reference configuration module connection pattern.

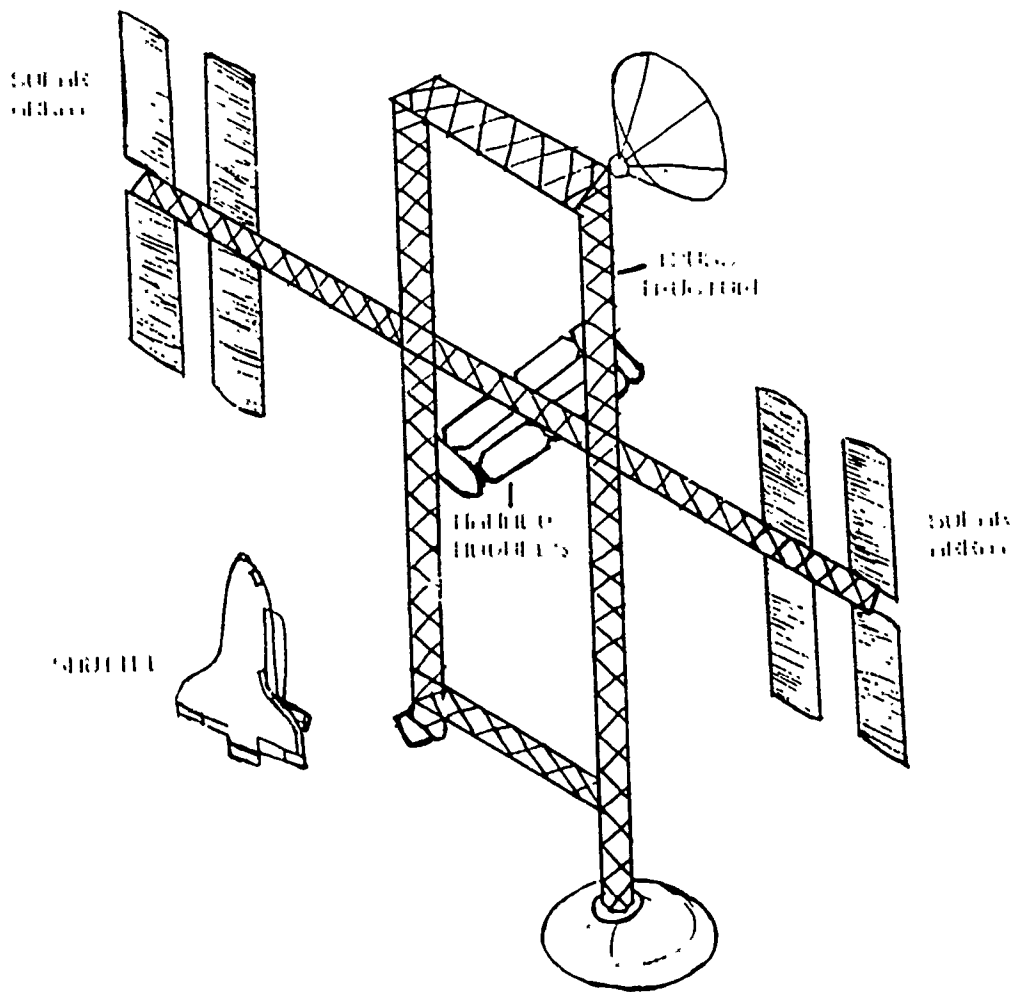


Figure 3.- Features of the Space Station.

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## V/STOL AIRCRAFT AND THE PROBLEM OF JET-INDUCED SUCKDOWN

Cherianne Carlisle

### INTRODUCTION

The purpose of this paper is to describe the suckdown condition encountered when jet-propelled, Vertical/Short Takeoff and Landing aircraft hover near the ground. A discussion of this ground effect problem and how it is being investigated will be followed by a more detailed description of one of the methods researchers are using to investigate the basic mechanisms that influence the suckdown condition. Specific parameters that will be taken into account include the height of the jet above the ground, jet exit conditions, and model geometry. Data from a current investigation will be presented along with some conclusions from other recent investigations in order to relate the significance of some of the parameters influencing suckdown. Suggestions will be made for some additional testing methods which might be useful to researchers investigating the mechanisms involved in jet-induced suckdown.

### BACKGROUND

In the Vertical/Short Takeoff and Landing (V/STOL) aerodynamics field, aircraft utilizing jet propulsion configurations are still in the process of being perfected (fig. 1). Though aircraft such as the Harrier have already been produced, researchers are still investigating the many problems inherent to the jet propelled V/STOL concept. One of the biggest problems currently under investigation is the condition known as "suckdown."

Suckdown is the negative lift induced when a jet propelled V/STOL aircraft is in hover just above the ground ("ground effect"). The negative lift, or down load, characteristic is a result of the entrainment of the surrounding air by the jet exhaust. When a V/STOL aircraft is in ground effect, the jet exhaust impinges on the ground and forms a stream of air that is called a "wall jet," in which air flows radially outward along the ground. As illustrated in figure 2, both the vertical jet stream and the wall jet entrain air, that is, they pull ambient air into their flow pattern.

The induced flow of air results in an area of low pressure directly underneath the aircraft. Meanwhile, the relatively motionless air above the aircraft results in a higher pressure than that of the air below. The product of the unequal pressures is a down load which acts against the lift created by the jets. The down load produced out of ground effect is not a problem due to the absence of a wall jet. The wall jet is significant because it greatly increases the surface area of flowing air which allows for a greater entrainment of the ambient air.

The problem of suckdown cannot be ignored. It results in loss of a jet V/STOL aircraft's net lifting capability in ground effect. Payload, handling, and control are also restricted by suckdown. Therefore, many investigations have been and are currently being performed by researchers in hopes of learning more about the factors influencing suckdown. Once researchers understand all of the factors, they will formulate some method to compensate for or overcome the induced down load. Due to the complicated flow field produced by multiple-jet configurations (fig. 2-b) (all current jet propelled V/STOL aircraft have two or more exhaust ducts), researchers often use basic models with just one jet (fig. 2-a) and a simple, flat planform in the shape of a circle or rectangle which represents the lower surface of the aircraft.

### SINGLE-JET SUCKDOWN

Single-jet suckdown investigations represent a simplified method for the examination of a complex problem. This method has both positive and negative aspects. The single-jet approach is extremely useful for analysis of jet characteristics and other basic mechanisms which influence suckdown. On the other hand, such an approach completely omits the vital "fountain" characteristic (fig. 2-b) which accompanies multiple-jet configurations. The fountain is formed when two or more radial wall jets meet and force their air flows vertically upward. Such an upward stream of air can actually reduce some of the down load on the aircraft by counteracting it with an upward force. Moreover, because so many added complications are involved with multiple jets and fountains, the single-jet configuration is necessary to study the roots of the suckdown problem so a reliable database may be developed for reference in future investigations with more complicated configurations.

The investigations of single-jet suckdown have revealed certain unforeseen complications. Basically, the margin of error between the large-scale tests, small-scale tests, and calculated predictions was found to be larger than what is permitted. Large- and small-scale tests need to produce results that closely agree; otherwise expensive, large-scale models have to be constructed each time an investigation is to be performed. The situation is almost identical in reference to calculated predictions. The margin of error between the calculated predictions of researchers and their test results indicates that they are not taking into account all of the factors that influence suckdown. Either the researchers aren't aware of all of the factors involved or they just don't understand suckdown characteristics well enough to develop reliable methods for predictions. It seems that the influence of ground proximity on jet-induced lift-loss is so great that normal empirical methods are no longer effective. Owing to this dilemma, researchers are focussing their attention on the formation of an improved database which will include the effects of all of the influencing parameters. If more reliable information is thus made available, prediction methods that are based on more than just straight empiricism may be developed. A more inclusive database will allow researchers to investigate the margin of error between large- and small-scale tests in order to correct the problem.

The prediction methods used previously have proved to be unreliable. The first definitive prediction method for jet-induced suckdown in ground effect was developed

by Wyatt (ref. 1). He showed how planforms with various diameters could be correlated on the basis of the height and diameters of the planform and jet. Though the basic framework for Wyatt's correlation has not been contradicted by investigations that have been run, his method doesn't account for all of the variables that affect suckdown. The jet pressure ratio, exit velocity distribution, size of the ground plane, and jet-induced turbulence are not represented as they should be in Wyatt's equation (ref. 2). The very same factors are not completely understood as of yet, but they are known to have an important influence on the flow field. Thus, researchers have been comparing their test results to a method that is not inclusive. This fact could explain why test data don't match prediction data.

The database used for large-scale investigations has been based on some questionable test results. The test results stated that a small-scale, cold, single-jet test could produce results that match full-scale data. The test this statement was based on produced lift-loss differences of three to five percent between the large- and small-scale tests run. Such a percentage of error is not acceptable and proves the test invalid. It has been shown that a mere two percent error in lift-loss predictions could translate into a ten percent reduction in payload capacity (ref. 3). Thus, the database that researchers use as a reference when performing investigations is virtually useless. This fact could help to explain the margin of error that exists between large- and small-scale investigations.

At the NASA Ames Research Center in California, researchers are currently analyzing the results from recent single-jet investigations they have performed in their outdoor test facility. Two sets of tests were run, a set of large-scale tests and a set of small-scale tests, in order to study the effects of scaling on jet propulsion, ground effect testing. The set of large-scale tests was made up of several runs using a YJ-97 turbojet for half of the testing and a TF-34 turbofan for the rest. To match the large-scale testing, the set of small-scale tests were divided into different types of air flow turbulence. The runs creating a less turbulent flow were to be compared with the turbojet, while the runs created with a greater turbulence level were to be compared with the turbofan tests. Both sets of tests were run using a square plane to represent the ground and a circular plane to represent the lower surface of an aircraft, and had a jet exit flush with the plane in the center of the circle. The two flat surfaces were parallel to each other and positioned at a ninety-degree angle from the ground (figs. 3 and 4). Though much of the data from the tests is still being analyzed, some conclusions have already been drawn.

Results from many recent tests, including the ones performed at NASA Ames, are the source of a constant flow of updated information that should produce a reliable database for future investigations. This information includes a much better understanding of many important parameters that influence the calculation of suckdown characteristics, new insights into which parameters influence scaling effects, and indications that investigation methods could be revised to acquire more precise data. Some of the more prominent parameters now being studied are the height of the jet above the ground, jet exit conditions, and model geometry.

The height of the jet and suckdown plate above the ground proved to be an important parameter that influences suckdown. As the height increases, the induced

down load decreases (fig. 5). The distance between the lower surface of the aircraft and the ground also has a key role in the process of suckdown. A decrease in the distance between the aircraft and the ground produces a need for an increase in the jet velocity, which in turn causes the air flow beneath the aircraft to move faster; faster moving air translates into lower pressure; lower pressure produces loss in height; and so the cycle continues. Though there are quite a few more parameters involved in the process that produces suckdown, this basic theory of infinite suckdown is valid. The fact that lower heights increase suckdown encourages researchers to favor an aircraft with higher wings.

There are several jet exit conditions that should be considered when evaluating jet-induced suckdown. A few of the more important exit conditions that are currently being studied are the nozzle pressure ratio (NPR), jet turbulence, and the exit pressure profile. The nozzle pressure ratio is the area-weighted average of the total pressure across the nozzle exit. In simple terms, NPR is a single value that represents the average pressure at the jet exit. Researchers are not all in agreement about the influence of the nozzle pressure ratio, though most agree that NPR has little effect on the ratio of lift-loss to base thrust. Part of the problem is that the lift-loss is linear with NPR, but thrust isn't, which introduces nonlinearities when the lift-loss is nondimensionalized by thrust. This effect is illustrated in figure 6. Jet turbulence is considered an important factor involved in creating the differences between large- and small-scale tests. The turbulence created by the jet affects the air flow pattern beneath the aircraft and thus affects the suckdown condition produced. Large-scale tests utilize real jet engines while small-scale tend to use compressed air to simulate jets; this difference in sources results in completely different jet-induced turbulence levels. Researchers have discovered that the use of screens will affect the turbulence a jet produces, but not in any uniform manner which would allow them to manipulate the situation. A method of controlling the jet exit turbulence level needs to be derived in order to produce equivalent turbulence levels for large- and small-scale tests that are to be compared. The nozzle pressure profile is the actual distribution of total pressure across the nozzle exit. In other words, it is a set of numbers that represent the varying pressure at the nozzle exit. Nozzle pressure profiles should be matched for tests that are to be compared in order to ensure equivalent suckdown characteristics involving pressure.

The shape and size of the model parts used in testing have been determined to greatly influence investigation results. The ground plane should be quite large in order to accurately simulate a landing pad. The jet to suckdown plate diameter ratios should be the same for tests that are going to be compared. Researchers consider model geometry to be one of the important factors causing the differences between large- and small-scale tests. For accurate analysis, researchers recommend that the suckdown plate be close to the form of an aircraft, not a flat circle or rectangle such as most current models use.

## CONCLUSION

In the Vertical/Short Takeoff and Landing field of aerodynamics, jet-induced suckdown is a subject of intense study. In the course of this study many discrepancies between prediction and large- and small-scale results were discovered. Before researchers would be able to resolve the discrepancies, they would need to gain a better understanding of the basic mechanisms that produce suckdown in ground effect. To begin to gain an understanding required that the researchers perform very basic investigations and slowly build a thorough and reliable database. The investigations that followed utilized single-jet test models with basic geometries. As the investigations continued, the data collected were analyzed and testing methods were upgraded. Recent investigations indicate that several parameters need to be examined in greater detail, and more realistic, scaled model geometries should be used. Now that a reliable database is being compiled, researchers will be able to expand testing methods back to models with multiple jets and this time they will have a greater ability to draw accurate conclusions.

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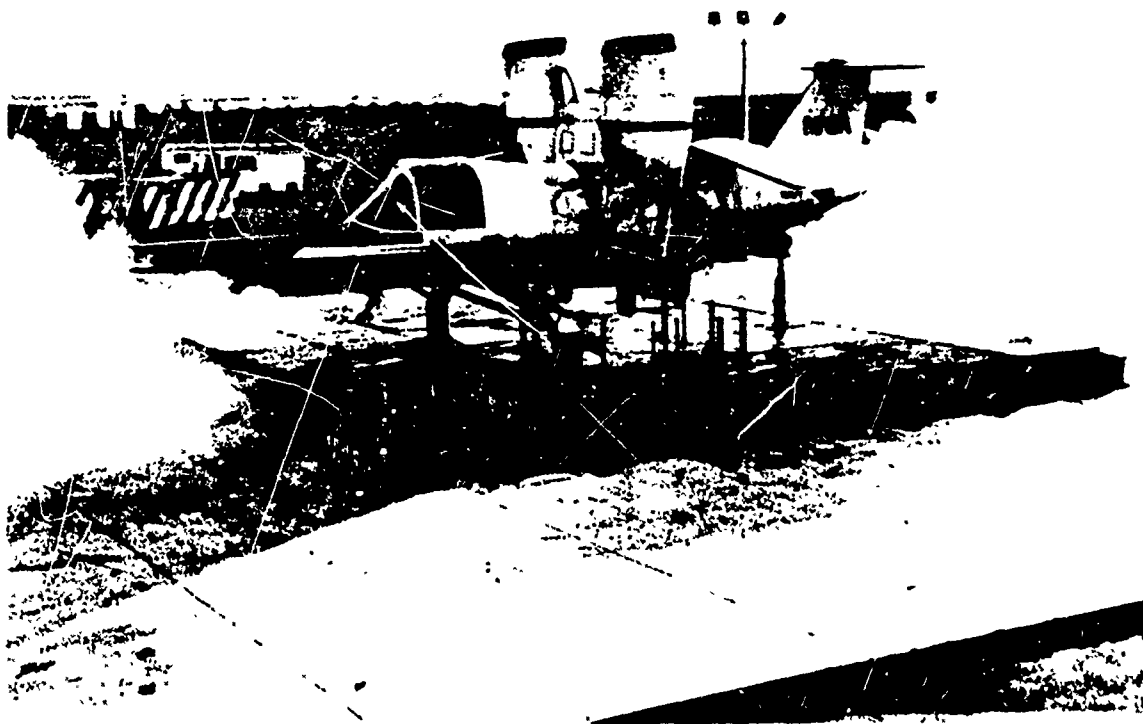


Figure 1.- Grumman twin tilt-nacelle V/STOL aircraft test model.

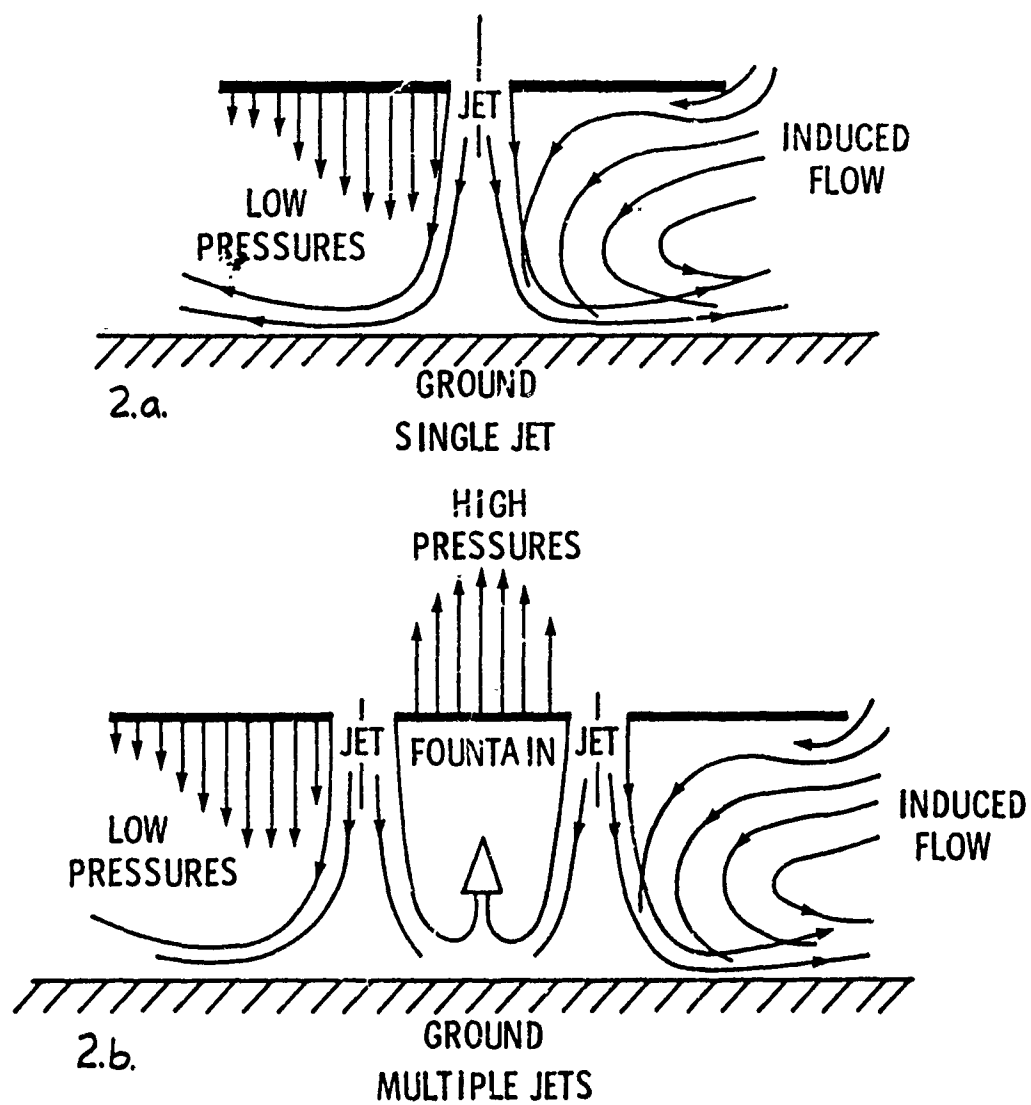


Figure 2.- Flow patterns near ground with single jet and with multiple jets (ref. 5).

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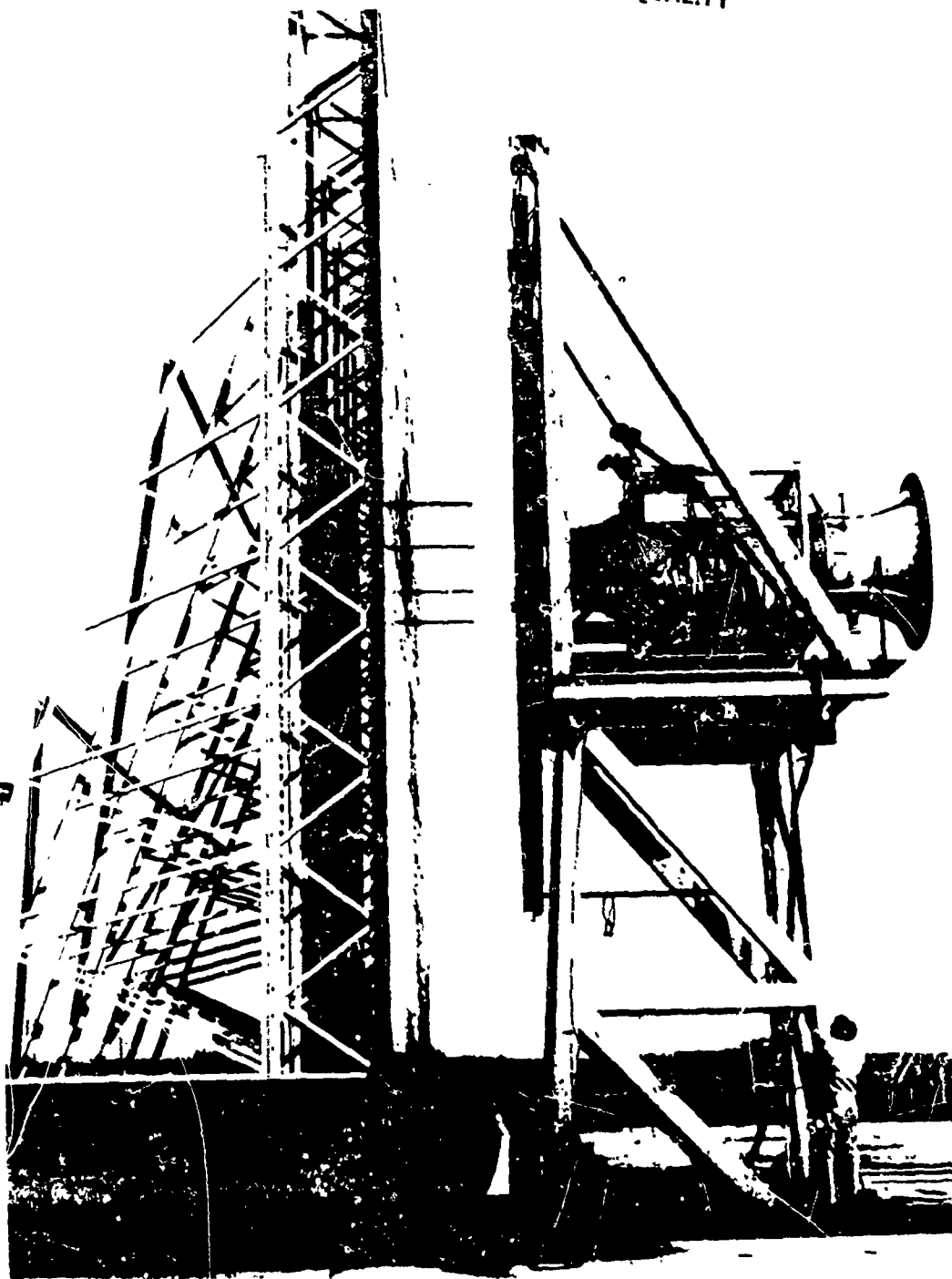


Figure 3.- Large-scale, single-jet test model with TF-34 at the NASA Ames outdoor test facility.

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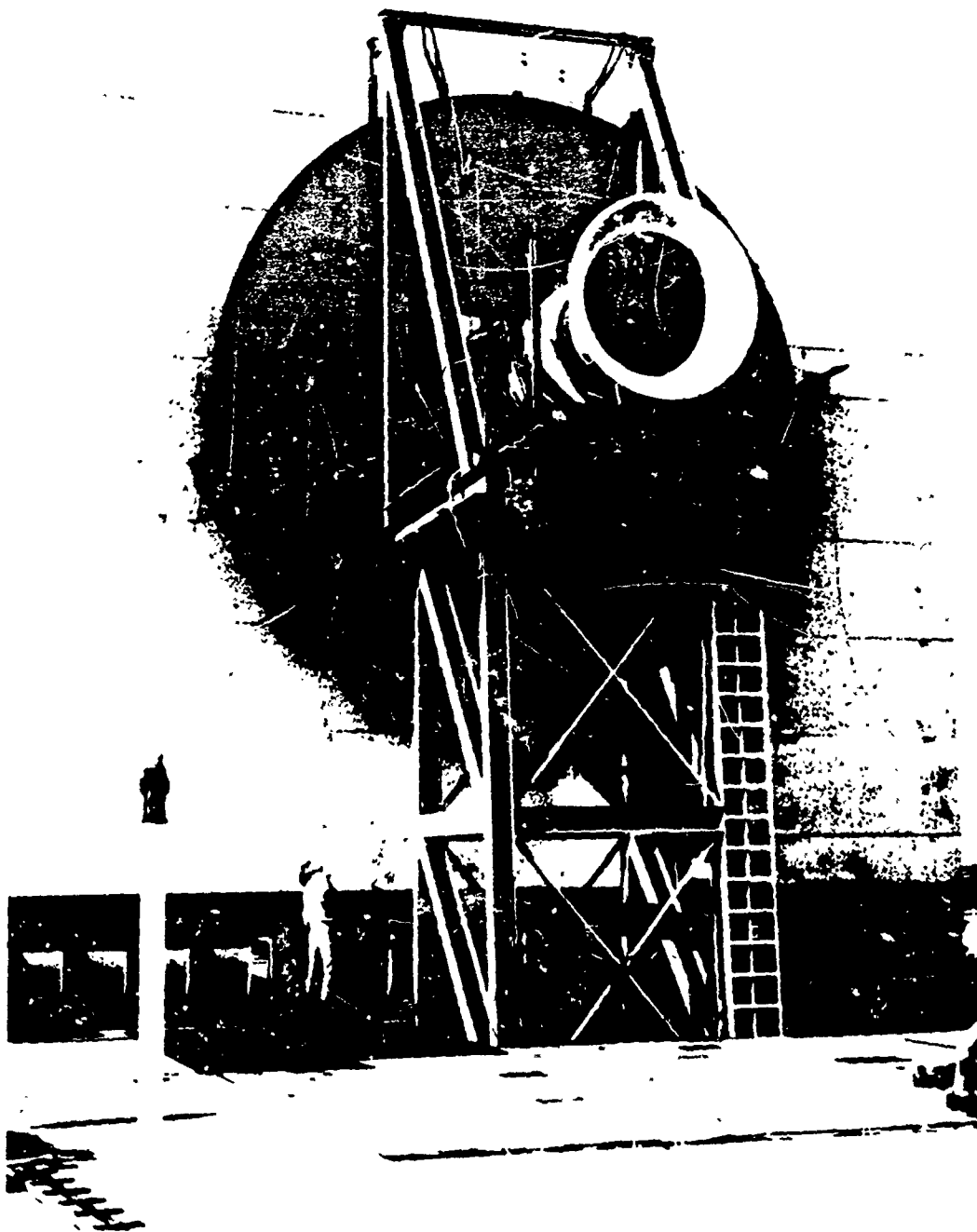


Figure 4.- Perspective 2.

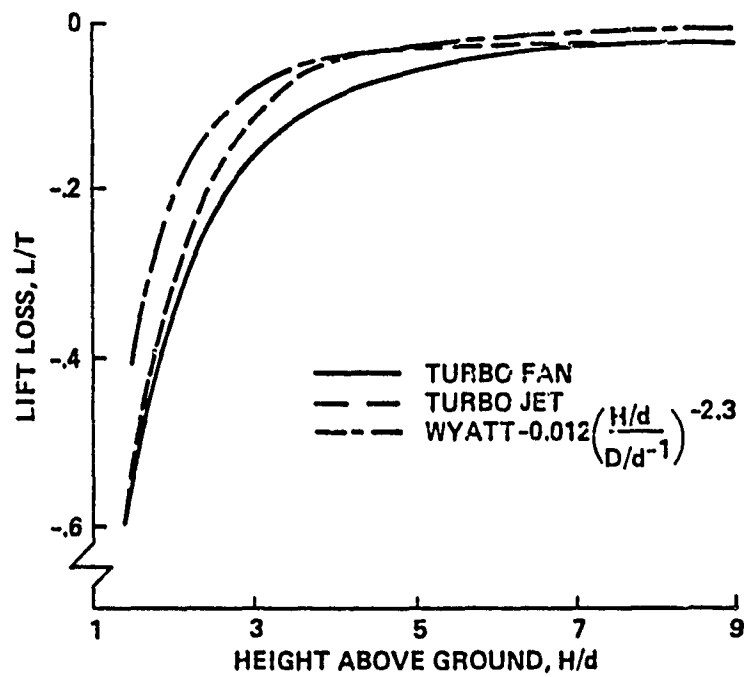


Figure 5.- Lift-loss vs height--as the value for height increases, the amount of negative lift decreases.

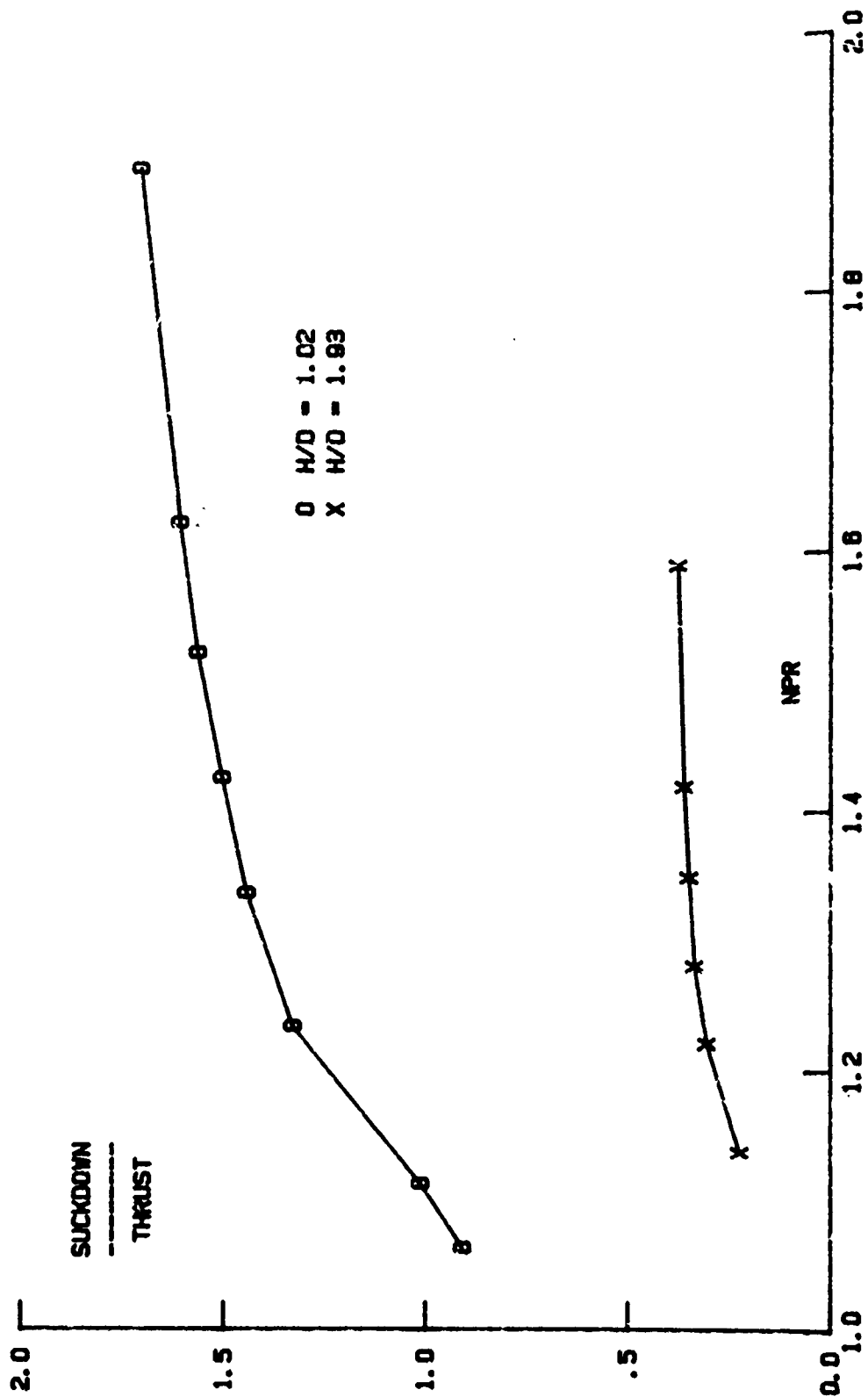


Figure 6.- Lift-loss to base thrust ratio vs NPR--the ratio value changes with changing NPR.

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## MOTION SICKNESS: CAN IT BE CONTROLLED?

David Carnes

Since the beginning of transportation by airplane, boats, and automobile, man has had to deal with the problem of motion sickness. Motion sickness, in general, affects a large percentage of the population regardless of sex, color, or age. It is the most underpublicized disorder in the world. Motion sickness, contrary to popular belief, actually produces changes in one's physiology. The motion sickness sensation is detected by the inner ear (actually the vestibular system); in particular, the semicircular canals. The semicircular canals are filled with a fluid, endolymph, which flows through the canals whenever the head experiences angular acceleration. Flow of the endolymph deflects the cupula, a structure which behaves like a dangling pendulum. The amount the cupula is deflected is communicated to the brain. These signals generate reflex eye-movements, termed "nystagmus," whose primary function is to maintain the stability of the visual world. The symptoms of motion sickness are different for each person. Some subjects show erratic changes in their heart rate while others show rises in skin conductance level. Still other individuals show increases in skin temperature by a few degrees Fahrenheit.

The National Aeronautics and Space Administration, NASA, is one of the few research centers concerned with motion sickness. Since the physiology of man has been developed in the one-gravity-field Earth, the changes experienced by man in space are unique, and often result in symptoms that resemble motion sickness on Earth. NASA is concerned with motion sickness because it is very uncomfortable for the astronauts, and after all, the astronauts are the "stars of the show." Another concern of NASA is the possibility of a motion sick astronaut regurgitating while he or she is sealed in an airtight space suit. Not only would this be "gross" but it could be fatal. The regurgitated food could obstruct the breathing passage of the astronaut and he or she could suffocate. Motivated by these reasons, NASA spent thousands of dollars in research and development for a drug or technique for combatting motion sickness. Several different treatments have been developed for this disorder. This research paper will discuss three of the most effective ways of combatting motion sickness.

The first and most common way of dealing with motion sickness is drugs. Drugs are a common solution to many problems and motion sickness is no different. Pills are widespread and varied. Some contain vitamins, others calcium. The advantages of drugs are their convenience. Drugs are right where you need them, day or night. E. M. Glaser and R. A. McCance in 1959 found that scopolamine may be helpful in some patients in preventing motion sickness. The most common drug prescribed by most physicians remains "antihistamines," which have demonstrated effectiveness in controlled clinical tests. Although drowsiness is a common side effect of antihistamines, the sedation may contribute to their effectiveness. The antihistamines have fewer adverse side effects than scopolamine.

A second technique involves natural adaptation to repeated exposures to motion sickness stimuli (e.g., being on a boat every day). Your body is such a great machine that a natural resistance may be developed. Sailors often call it "getting your

sea legs." This principle of adaptation is not only applicable to sailing but to space travel as well. Darwin's "Origin of Species" discusses the possibility of man evolving around the need to change in order to survive. Based on this principle the theory of evolution was born. If one accepts the theory of evolution then he or she can expect or conclude that if man were to permanently stay in a weightless environment a physiological adaptation should occur. This adaptation would allow humans or their offspring to live in a weightless environment without becoming motion sick. The cost of designing, building, and deploying a facility capable of sustaining life for nine months (the time for a child to be born) would engulf the funds NASA has available. There is no guarantee that the child born would be resistant to motion sickness or would want to become an astronaut when he or she matured.

A third method of combatting motion sickness is a physiological conditioning procedure called Autogenic-Feedback Training (AFT). AFT is a procedure which enables human subjects to gain voluntary control of several of their own physiological responses simultaneously. The training technique AFT will use is a modification of a procedure known as biofeedback conditioning. Biofeedback provides a means of becoming aware of physiological activity. A consensus of researchers believe that once one is made aware of some bodily activity, then he or she can learn to influence the response to that activity. For example, we can learn to play the piano by pressing keys on a keyboard; our ears tell us whether or not we pressed the right note (i.e., made the right response). If we press the wrong note the information is conveyed to the brain (via neural pathways) and our brain then directs our fingers to the correct key on the piano. In this way, an information "feedback loop" is set up between the brain, the muscle of the finger, and the sense of hearing. And with practice we can eventually learn to hit the right keys. This same "feedback loop" is applied during an AFT test for preventing or controlling motion sickness. The subject is provided with the necessary equipment to monitor his or her own physiological activity during an AFT test. If the subject notices a dramatic change in physiological activity (such as erratic heart-beat) before or while he or she feels the symptoms of motion sickness and is trained to control these physiological responses, the AFT conclusion would be that the severity of the motion sickness symptoms would diminish.

Which of the aforementioned methods are the best? Well, the best way to determine that would be to look at the pros and cons of each method. Drugs have the convenience factor, while natural tolerance has the unprecedented tradition; and AFT has the computer technology of the eighties. Drugs (unlike natural tolerance) take only a few minutes to be effective. Antihistamines (though effective) are proven to cause drowsiness. Natural tolerance would be great for the "frequent flyer." But for the occasional traveler the rational prescription for discomfort due to the sensations of motion (other than natural motion) would be antihistamines. The decision would depend on how much time you have and how you felt about the health of your body. But in either case drugs would be an effective method of diminishing motion sickness symptoms.

Drugs would seem to be a better method of dealing with motion sickness than natural tolerance, but what about AFT? Well, AFT and natural tolerance both work on the principle of the capability of the body to adapt to adverse situations. The major difference is AFT voluntarily controls bodily functions (i.e., heart rate) whereas natural

tolerance is controlled subconsciously by the brain. The advantage of AFT over natural tolerance is that a person can be trained in a few hours while natural tolerance takes longer to be as effective.

The question to be answered in the 1990's is whether AFT is more effective than drugs. If AFT is proven to be more effective a whole new medical field is created. Pharmacists and doctors await anxiously.

Motion sickness is a disorder that affects 95% of all people. It is a disorder that is not very serious but nevertheless is important to control. The research and development world is closing in on the cause and treatments of motion sickness, and it won't be long now.

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## IBM PC ENHANCES THE WORLD'S FUTURE

Jozelle Cox

Human beings have always been intrigued by the meaning of their existence and enjoy pondering over ideas that will enhance that existence. Having the interest in their past that they do, humans have often used the materials and substances of their surroundings to enhance human existence. The curiosity one has about the past, as well as curiosity about the environment leads one to creativity, and one soon feels a need to accomplish the goal that curiosity has made possible. Fortunately, the curiosity and creativity of the human race has remained prominent in the present day and age. In today's society, man has set and accomplished goals that range from putting men on the moon to a development now in progress--an aircraft that can reach orbit and return to Earth just as easily as it reached outside the atmosphere. The need to attempt to be "all one can be" is a feeling that resides in the human race, and can easily be seen through the continuous achievements in another area of interest. Although the purpose of this research is to illustrate the importance of computers to the public, particularly the IBM PC, present examinations will include computers developed before the IBM PC was brought into use.

The human interest in the use of machines to aid his/her existence began as many as 5,000 years ago, but the first major breakthrough stemmed from the development of the arithmetic machine in 1642 by Blaise Pascal. The machine contained eight wheels having the numbers zero through nine printed on them. These wheels were attached in such a way that dialing a certain amount to be added or subtracted created the world's first computer. With this new development came the curiosity to learn more and improve the present novelty; this is most likely what led Leibnitz to develop what is now called the binary system, and that development gave Charles Babbage the desire to create the Analytical Engine in 1835, or as it is more popularly termed, the keypunch machine. Borrowing punch cards from the Jacquard loom after its revision in 1837, Babbage developed a mechanism that was to become an asset to millions of people, and the grandeur of that machine led to the development of the MARK I Automatic Sequence Controlled Calculator. Financed by the Navy and built by the Computing Tabulating Recording Company (now IBM), the MARK I was similar in operation to Babbage's Analytical Engine. The new machine, which used punch card input/output, was operated by mechanical relays and stored numerical data. Having a design that contained 760,000 wheels, 500 miles of wire, and a panel 8 feet high and 51 feet long, the MARK I could execute 200 steps per minute. The public was fascinated by its mechanical ability, and its ability to perform tasks easily. But as the need grew for tasks to be completed more quickly, so too did new developments in computers evolve, and in the 1930s, when electronic components were successfully employed, the real breakthrough in computers was disclosed. From 1937 to 1945 the ENIAC was designed to aid the public as much as possible. The new computer weighed in at a very heavy thirty tons, but had electromechanical input and could perform 300 multiplications per second. Following the ENIAC was the UNIVAC, which became an industry leader in the early years of computers.

The first generation computers served the public in many different ways, but had many flaws ranging from their large sizes to their ways of often making mistakes,

especially with tricky functions such as punch cards and binary codes. The users of these computers saw a need to improve on the first generation machines in a way that allowed the public to understand easily and communicate with them. With this goal in mind, in 1954, the IBM 650 was developed. Using a drum for main storage, it became the workhorse of the industry. This new machine was an asset to many as well as the predecessor of more advanced computers to follow. It allowed for large amounts of information to be put on a small device called a microchip, and it replaced the old punch cards with magnetic storage tape for input and output, thus making the machine more lightweight and easier to operate. The new assets appeared to be a great convenience to all users, but its inability to be compatible with other computers presented a problem, and for this reason, development of operational systems followed. These new systems allowed the user to communicate in one language with all related machines by giving a certain command at a certain time. Eventually the 650 was replaced by new computers which, with the help of operating systems, could perform tasks much faster than their predecessors. These computers are in wide use today, especially in homes and in the business world. One example of the resources gained from the use of the IBM computers is evident at NASA Ames Research Center. To perform their daily tasks, researchers at NASA Ames use many IBM computers, and one in wide use is the IBM Virtual Machine Storage System.

With the development of new operating systems and software to increase computer compatibility, the user has been able to pool the resources of the IBM VM open and closed systems. Some of the features that allow users to manipulate the open systems to their advantage include the UNIX operating system, a multiuser operating system. Developed in 1969 by Bell Laboratories, its many assets have contributed to user production of programs and files. One system using UNIX is TITAN, a networking system that allows one user to talk to another through his/her computer. TITAN allows the users to not only communicate in a "phone" mode with each other, but to send electronic mail to users the world over.

Another multiuser system in wide use at NASA Ames is the VAX system. Primarily using a database management system, this program allows the user in the business world to keep a running file on information that is frequently changing. Since the information kept on a database file is constantly changing, it is an aid to the user to have a system that automatically changes calculations and the like with just a few entries to call up the previous information. One VAX system used by data enterers and systems analysts is SATURN, and this program also has networking abilities.

Finally, the IBM VM Storage System contains its own operating systems for personal or mainframe computer work. One operating system in wide use in business is the Conversational Monitoring System, and it is special because it allows a user to communicate with the mainframe as a personal computer. CMS is a unique mode of operation of the IBM, as it keeps all one's work under a category called FLIST; all the user must do is give all materials a filename, filetype, and filemode, and the information can be recalled at any time by going through the FLIST mode. A user may also create or delete new files at any time he/she wishes, and revisions are also fairly simple with the use of a few commands.

Once the user has recalled the information he/she needs, he/she may choose to XEDIT or XEDIT UPDATE that file. XEDIT mode allows changes to be made to the previous version of information by listing a particular file exactly as it was saved, and the user may scan that file and make changes exactly where needed; the program is then saved again, and the user's time can be spent on other projects. Other changes may be made to files by first sorting them in a certain fashion. SORT-BY-DATE, SORT-BY-NAME, and SORT-BY-TIME quickly bring already-sorted files to the user. One can also delete files to save the file space; this also helps to sort the stored information. Being able to create files and recall them in CMS becomes very helpful, as the Conversational Monitoring System allows the user to open a library system called NATURAL, and the knowledge of this system allows documents and descriptions on file to be edited at any given time.

By using the IBM computer in a PC mode, the user can access the resources of the personal computer. The workings of the IBM PC "bridge the gap" between personal computing and mainframe computing. Some of the PC's most attractive features include the IBM's ability to work on one computer system, and send or punch the results or file to another user; the ability to communicate or "network" with other computers (e.g., IBM connection to VAX); and the IBM's ability to work on one system when another part of the networking group is not functioning properly. Other features for more personal use include a program called LOTUS. This program also contains files in a database management form, but LOTUS is considered "user friendly" in comparison to normal database systems, meaning that LOTUS is easier for the end user to understand. Another program also available for personal use is WORDSTAR. This system is a word-processing data file. A unique program, this system allows the user to store written documents (public and private) and make minor changes before the material is completed. WORDSTAR is much easier to use than a regular typewriter as typewritten work cannot be edited by any other means other than a manual one.

The public has made wide use of the IBM features of computers in a variety of ways. NASA Ames Information Systems Branch has used this machine to help redevelop the PMIS procedures for the Office of Personnel and Management, and the Central Computing facility has used the IBM PC for database management, word-processing, and graphics to aid in the design of computer systems. Home users have become very adapted to LOTUS, for this program is a major part of their home financial management.

IBM, as well as other computing facilities, began serving the public years ago, and is continuing to find ways to "enhance the existence" of man. With new developments in supercomputers like the Cray-2, and the recent advances in "artificial intelligence" (AI) programming, the human race is gaining knowledge at a rapid pace. All have benefited from the developments of computers in the world; not only have they brought new assets to life, but have made life more and more of a challenge everyday. The pride in the old as well as the new creations have led many individuals to believe that only "the sky was the limit" and one could continue to achieve to the best of one's ability. As new computers come into play all over the world, may all individuals continue to seek knowledge, but above all, gain wisdom.

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## THE POSSIBLE CONTAMINATION OF JUPITER

Joe Garcia

Centuries ago, when the first Anglo pioneers invaded the shores of the Americas, they brought with them more than just the hope and will to survive that we normally associate them with. They carried with them on their ships, their clothes, their cargo, unseen microorganisms, bacteria and disease. North America, and the Native Americans who inhabited it, being isolated from Europe by the Atlantic Ocean, had never before encountered these foreign bacteria. The "pilgrims," on the other hand, had not only coexisted with their domestic diseases, but had battled viciously with them and eventually built up an immunity which protected them from being overridden by bacteria. The Native Americans had no such defense system, and as a result of that, the bacteria thrived in the pure environment of the New World. Now keep in mind that these were not any bacteria of the complex sort; no, these were quite ordinary bacteria, predominantly just the common cold. But because these bacteria were in no way common to the uncontaminated Americas, the disease spread like wildfire and was responsible for more Native American deaths than any head-scalper.

This contamination of North America was not planned. Man knew little of life invisible to the naked eye, and even less of the catastrophic reaction to these new microorganisms that the Native Americans displayed. The New World, as America was referred to in the first years of its "discovery," was a land full of mysteries to be solved. Explorers came from every land in an attempt to untangle and map out the unknown geography that North and South America represented. They came on a quest for knowledge, hoping to find a relative Garden of Eden and steal its forbidden fruits.

Well, now it's 1986, and "The New World" is completely charted, its lands tamed. Satisfied with our knowledge of this now old world, we look beyond our own planet, into space, hoping to find newer worlds. There are at least eight others out there, future sites of expeditions and explorations, waiting for rocket-boasted Mayflowers to arrive. Space, perhaps the final frontier, a vast, uncharted sea. The days of exploring new continents are long over, and, as history repeats itself, the people of Earth enlarge their perspective to include other planets, the solar system, the universe. What a beautiful and pacifying new sea upon which will embark a new breed of explorers!

But like the pilgrims, will space explorations represent a threat of bacterial invasion? Bacteria are one of the most basic of Earth's organisms, hypothesized to be one of the turning points in our own evolution. It is said that the simpler things are, the better they are. Well, this is most certainly the case when we take into account the great capacity for survival which bacteria have. Temperatures much too hot for any human to survive in are no sweat (no pun intended) for most bacteria. Bacteria can survive in inhumanly cold temperatures just as easily, and are even able to exist on the outermost hulls of ships in the vacuum of space.

It is inconceivable to totally condemn the pilgrims for their contamination of the New World; they simply didn't know what they were doing. But now we know about bacteria, and we know that they will survive space travel. Contamination becomes less of a laboratory issue and more of a moral dilemma because we know what we are doing. Is it not the hope of NASA to someday discover other forms of life, perhaps intelligent life, on planets beside our own? And if the answer to this question is yes, then wouldn't any type of bacterial invasion deeply risk reducing our chances?

The only way to avoid contaminating an alien environment with terrestrial organisms is either to completely sterilize any and all equipment/persons that come into contact with the environment, or else simply not to come into contact with it. If we must come into contact, then it is the logical and responsible choice to sterilize as best we can. It takes only one bacterium to start an epidemic. Sterilization has been met with much skepticism and much dislike. Not only does the present method of extreme heat cost a great deal, but it also forces the developers of space exploration to face new problems. Bacteria can survive high temperatures which can ruin the most intricate and complex parts of a space vessel, such as its circuit boards. So when designing landers and probes, scientists must be extra careful that their final product will survive the heat of sterilization. The early Ranger series, intended for exploring the moon, met with this difficulty and could not be made to function properly after sterilization.

The Viking mission, however, is a testimony to our ability to sterilize spacecraft without creating malfunctions. It's true that Viking took a great deal of money, time, and more money, but the final product passed the test. Though it was proven that Viking was not totally sterile, it was a cornerstone in space sterilization.

Recently, there has been much concern regarding the fact that the Galileo probe, though its fate is now uncertain, will be the first probe ever which will not be sterilized. Designed to enter into the atmosphere of Jupiter, the probe will simply take readings and measurements as it falls to its eventual death. It was thought that the Galileo probe need not be sterilized, for Jupiter was considered to be an environment where the chances of contamination are "nil." Most assumed that no terrestrial life could live on the planet, but is that an accurate assumption?

#### BACKGROUND INFO ON THE MODEL

Jupiter, to the best of our knowledge, is completely composed of gases. Like Earth, its temperature increases as one gets closer to the center, its core an inferno. There are various vertical layers in Jupiter's atmosphere, and particles can travel from one layer to another by two primary means. The first way is simply by gravity; the particles are pulled to a lower layer by Jupiter's own gravitational force. Countering the effects of gravity on Jupiter are conditions such as winds, turbulence, and heat, all of which cause particles to rise to a higher level. This process of rising and falling is known as "mixing."

The main argument against bacteria surviving on Jupiter is that it is believed that there will be little, if anything, for the microorganisms to eat. Without substantial

nutrients, bacteria cannot multiply and will eventually be pulled down by gravity to a layer whose temperature is too high and will cause combustion. If bacteria can get enough food to multiply and reproduce, then, even though some bacteria will perish in lower-layer infernos, others will survive and reproduce more, continuing the legacy of bacteria. If there is enough food, the bacteria will reach a point of equilibrium in their reproduction; this point is achieved when the number of bacteria being produced is equal to the number which are being destroyed, thus yielding a constant number of bacteria.

Well, is there food for bacteria on Jupiter? Yes, there are substances known as "tholins" which have been proven to be a good carbon source for bacteria. Tholins are organic compounds which are produced by mixing gases, such as methane and ammonia, and then exposing this mixture to some form of energy. The energy transforms the simple ammonia-methane mixture into complex chains of molecules (amino acids) which bacteria can then live on. Jupiter has gases in its atmosphere which will mix, and, when exposed to energy such as lightning or sunlight, produce tholin, which the bacteria can then use as food. But will there be enough food to allow enough bacteria growth to overcome the loss of many bacteria in the gravitational pull? In other words, will the bacteria be able to reproduce faster than the rate at which they will be killed?

Due to the varying temperatures of the Jovian atmosphere, bacteria growth is limited to a certain atmospheric region. This area is known as the habitable zone. Characteristically, it is bounded by temperatures ranging from 0 to 100 degrees Celsius, since those are the parameters within which water is in its liquid form, a necessity if bacteria are to grow. Bacteria can only grow while in the habitable zone, and therefore growth is limited by how much tholin enters this zone. The process of "mixing" plays a key role in the bacteria's survival. Will the bacteria, at the mercy of the mixing process, stay within the zone long enough to encounter tholin (another traveler dependent on the mixing process), eat it, and produce more bacteria? How much time do the bacteria have to find food, eat, and then double before they are swept away? If the mixing process does not allow the bacteria enough time to complete this cycle, bacteria will not be able to exist on Jupiter. However, if there is an adequate amount of time in which the bacteria can fulfill their survival obligations, then bacteria will more than likely thrive.

### THE MODEL ITSELF

A computer model simulates Jupiter's conditions. It regards two things when testing to see if bacteria will survive: 1. altitude (are the bacteria in the habitable zone, how much has drifted out of the zone), 2. time (have certain bacteria been in the zone long enough or too long, at what time should they naturally be mixed out of the zone). Not only are these two dimensions applied to the bacteria, but to the tholins as well. (How much tholin is in the biozone, did it all get consumed by the bacteria, is there an excess, how much tholin has left the zone, how much has entered.)

The simulation program suggested that bacteria would indeed exist and multiply within Jupiter's atmosphere, and that the point of equilibrium would be reached

approximately one year after the initial contamination occurred. Once bacteria enter Jupiter, there is no getting rid of them. Total colonization by the bacteria would be achieved.

Two notable errors in the program's simulation are:

1. The time step between each mixing occurrence was too large. It allowed too much time for the bacteria to eat and reproduce.
2. It was assumed that the tholin which entered the habitable zone would be consumed if needed by the bacteria. No consideration was given to the fact that the tholin must come in contact with the bacteria for them to eat it.

Regardless of these flaws in the initial simulation, bacteria would still, most likely, thrive in the Jovian atmosphere. The point of equilibrium may not be reached in the time given by the initial simulation, but the point would be reached. Also, the quantity of bacteria, which was phenomenally large, would be reduced, of course.

## CONCLUSIONS AND AFTERTHOUGHTS

The Galileo probe, though at present its future is uncertain, would, if not sterilized, represent a good chance of contaminating Jupiter. Most scientists opposed to sterilizing the probe argue that to order the probe sterilized at this point would be the death of the project, since sterilization would entail a reconstruction of the probe, and there are just not enough funds to accomplish this. These scientists, however, are ignoring a relatively simple and inexpensive alternative to the traditional heat sterilization method. The main threat of contamination comes from Galileo's exterior surfaces: the shell of the probe and its parachute. The probe's innermost components would not represent a threat since the probe is sealed. In light of the fact that only the exterior of Galileo would have to be sterilized, heat would not have to be used as a method of sterilization. Instead, various gas mixtures could be sprayed entirely over the probe and its parachute, gases which would kill any and all bacteria. Though this method could fit in the Galileo budget, it is being overlooked. Why? Certainly the avoidance of contamination is worth the small amount of time and money that this alternative sterilization would cost. Isn't it?

Bacteria appear to have played a key role in our evolution. Jupiter, a planet which appears to be in a far more primitive state than ours, may be involved in its own evolution. Surely any terrestrial bacteria would jeopardize this evolution by either eating or destroying any domestic microorganisms, or by producing mutant bacteria and new breeds, interfering with the original destiny of Jovian evolution. And how would we know, many years after the contamination, if any life we then discover on Jupiter is its own, or simply our own unrecognizable mutant leftovers? We have a responsibility to make moral decisions when dealing with space exploration. Is that not one of the main aspects to space exploration in the first place, to learn about other worlds and hopefully other beings? The information that the Galileo probe would furnish is not enough to take such a risk. Contamination is too possible.

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## THE VERTICAL MOTION SIMULATOR

Todd Hosein

Flight simulation has progressed greatly in the past twenty-five years. The first immobile flight simulators pale in the presence of contemporary technological advances in flight simulation. Today's flight simulators, such as NASA's multimillion dollar Vertical Motion Simulator (VMS), recreate an authentic aircraft environment, and reproduce the sensations of flight by mechanically generating true physical events. A pilot trainee may receive practice and experience without the risk of actual flight test activities. Therefore, there are very few surprises when he/she takes his/her first real flight. New aircraft design concepts may also be tested. For instance, simulation was used to examine the Space Shuttle idea in its early stages.

In the Vertical Motion Simulator, the pilot sits in a cockpit that is a realistic replica of the aircraft being studied. It is used primarily to simulate the Space Shuttle, helicopters, tilt-rotor aircraft, Harrier jets and other aircraft that take off and land vertically. Cathode ray tubes, which are mounted on the cab where windows would normally be found, show computer-generated imagery to the pilot. This provides the visual aspect of the simulation. Computer-generated flight sounds are piped into the cockpit via speakers placed in the cab, bringing audible reality to the simulation. In addition, a powerful electrohydraulic motion drive system moves the cab through simulation maneuvers. This motion system can move the cab through six axes. These three systems, in conjunction with flight controls and instrumentation in the cab that respond realistically, duplicate flight conditions accurately. Digital computers have also been incorporated into the VMS facility. They compute the pilot's control inputs and produce signals which command the visual, audio, and motion generators to provide various cues to the simulator pilot. In addition to managing the current maneuver, the computer system must keep the cab near the center of the simulator chamber to allow for maximum mobility on each successive maneuver. The cab is programmed to assume a more neutral position in the chamber in movements that are inconspicuous to the pilot.

The visual display systems of the Vertical Motion Simulator are paramount to the consummation of realistic simulations. Before the introduction of computer-generated imagery (CGI), a closed-circuit television system was used. Television cameras, mounted on mobile scaffolding, filmed two large three-dimensional terrain models at various angles. The terrain models have features that range from cornfields to an aircraft carrier at sea. The recent computer-generated imagery system displays terrestrial features as well as runways, ships, and other aircraft. It can also simulate changing weather and visibility conditions on a panoramic windshield scene.

The audio component of the VMS is comparable to the synthesizers used by many of today's musicians. This system can create engine noises and the rumble of wheels, and is so precise that it can reproduce the changing sounds of air flow outside of the cockpit.

Though visual and aural cues are sufficient for many flight simulations, many aircraft simulations require a motion drive system that can reproduce the movements felt by a pilot during an actual flight. The VMS motion generator consists of a synergistic electrohydraulic motion system mounted on a moving platform with large lateral and vertical capabilities. It duplicates the physical sensations of actual flight and guides the cab over a wide range of motion. Vertical motion is the primary degree of freedom and all other modes are ancillary, yet quite essential. The VMS is specially designed to provide a six-degree-of-freedom motion capability, including sixty feet of vertical motion, forty feet of lateral motion, and eight feet of longitudinal motion. This unique facility can also roll plus or minus twenty-two degrees, pitch plus or minus twenty-five degrees, and yaw plus or minus twenty-nine degrees.

In the last few years, three major revisions have been made on the Vertical Motion Simulator here at NASA Ames Research Center. The new Control Data Corporation (CDC) 7600 Computer has proven to be much more effective than its predecessors, the Sigma 7 and PDP 11/55 digital computers. The Interchangeable Cab System (ICAB) enables the simulator cabs of various aircraft to be mounted on the main platform. Lastly, computer-generated imagery has been substituted in place of television scenes, allowing for a wider range of visual images.

The Vertical Motion Simulator is managed completely by a network of computers, the nucleus of that network being the Control Data Corporation (CDC) 7600 Computer. This system offers a notable increase in computing speed over previous computers, and can be programmed to simulate various aircraft such as a 747 airplane, a Harrier jet, an F-14 jet, a helicopter, or a Space Shuttle. It is used primarily, however, to simulate aircraft that take off or land vertically or on a short runway. This large scale computer also has the capability to simulate several aircraft on different simulators, simultaneously. The flight simulation program for the CDC 7600 includes mathematical equations which are associated with the aircraft's position in space, flight characteristics, and the specifications of the aircraft being simulated. As the pilot operates the cockpit controls, signals are sent to the computer. The computer interprets these signals and calculates the proper response of the aircraft instantaneously. The computer then issues the appropriate commands to the motion drive system, the flight instrumentation, the audio system, and the video system, to provide the pilot with representative aircraft responses and flight environment. The entire process, which includes the generation of sound, motion, visual effects, and instrumentation response, occurs in mere milliseconds.

Unlike other simulators with a single fixed cab, the Vertical Motion Simulator incorporates the newly developed Interchangeable Cab System (ICAB) to allow increased operational efficiency of the flight simulator. Testing and fixed-based checkout of the cabs can be performed at the development station while the motion system remains free for maximum use in simulation investigation. For maintenance purposes, all of the cabs have been constructed with removable canopies.

The Interchangeable Cab System consists of three operating interchangeable cabs and a development station with provision for two other cabs. Two more cabs are now in development. All of the cabs are designed facsimiles of original cockpits from different aircraft, and each is outfitted with a sound system which amplifies the sound

of helicopter blades, landing gear, and touchdown, engine, and mechanical noises through four strategically placed speakers in each cab.

There are three ICABs currently in use at NASA Ames Research Center. The first has capabilities ranging from transport aircraft, such as the 747, to high performance vehicles such as the Space Shuttle. It has two seats, placed side by side. The second is an advanced helicopter cab, which is designed to look and handle like helicopters in the developmental or testing stages, such as Rotor Systems Research Aircraft (RSRA). The third ICAB in use is referred to as the "generic helicopter," and has the programming variability to be any rotorcraft. The two other ICABs now in development will be a single-place cockpit with fighter capabilities, and an Advanced Cab and Visual System (ACAVS).

The Flight Simulation Program at NASA Ames Research Center is one of the most advanced in the world. Ames aircraft simulators and human testing devices are used exclusively for research. About sixty percent of the operation time of the simulators is devoted to NASA's aeronautical research. The Ames facilities have been used to investigate most civilian aircraft as well as the Space Shuttle, tilt-rotor aircraft, and the Apollo lunar landing craft. Another thirty-five percent of Ames simulator operation time is used in cooperation with other governmental agencies. Experimental programs run by the Department of Defense occupy a large portion of this time. They have used the simulators extensively to investigate flight instrumentation which is superimposed on the windshield for easy visual access. This idea is also being tested by the Federal Aviation Administration for use in commercial aircraft. Also, the National Transportation Safety Board uses Ames facilities to determine the cause of aviation accidents. They do this by reconstructing crash scenarios using Ames simulators. The remaining five percent of Ames simulator operation time is devoted to the study and advancement of simulation technology.

In addition to their application as a training tool for pilots, simulators have become essential in the design, construction, and testing of new aircraft. Simulators allow engineers to study an aircraft's flight performance and characteristics without the cost or risk of an actual test flight. Because of their practicality, simulators will become more and more important in the development and design of new, safer aircraft.

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## **VERTICAL MOTION SIMULATOR (VMS)**

**AMES RESEARCH CENTER**

### **PRIMARY PURPOSE:**

- EVALUATE/DESIGN OF
- FLIGHT DYNAMICS
- HANDLING QUALITIES
- V/STOL FLIGHT SYSTEMS
- CONTROLS

### **KEY CHARACTERISTICS**

- 6 DEGREE OF FREEDOM
- $\pm 30$  FT VERTICAL TRAVEL
- DIGITAL/ANALOG DEVICES
- 2 MAN COCKPIT
- SPLITTER MIRROR DISPLAYS
- AURAL CUEING SYSTEM WITH ROTORCRAFT SOUNDS

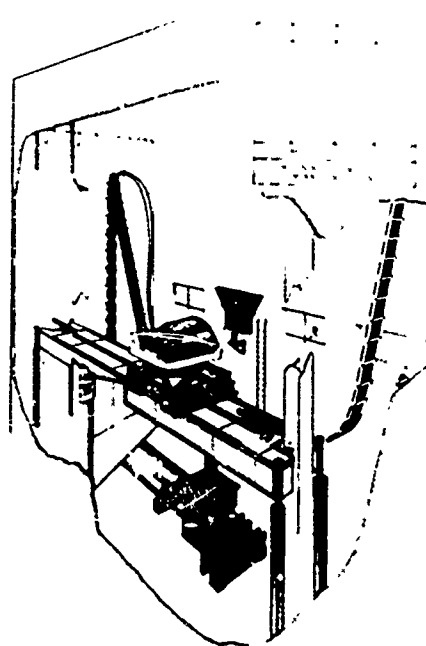


Figure 1.- Vertical motion simulator (VMS).

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## CIVIL ENGINEERING

Katie Kenning

Civil engineers are concerned with the structures in which we live and work, the transportation systems by which we travel, and the environment around us. They plan, design, and supervise the construction of facilities essential to modern life in both the public and private sectors. Facilities that vary widely in nature, size and scope: space satellites and launching facilities, offshore structures, bridges, buildings, tunnels, highways, transit systems, dams, airports, irrigation projects, treatment and distribution facilities for water and collection and treatment facilities for waste water.

If one becomes a civil engineer one will be in the forefront of high technology's newest application; one will be involved in community development and improvement; one will be a problem solver, a doer. The opportunity for creativity is unlimited, since each end product is custom designed.

There are basically seven different fields of civil engineering: structural, water resources, geotechnical, environmental, construction, and survey engineering. Within each of these seven different disciplines of civil engineering one could become even more specialized by choosing between design, construction, research, teaching or management.

Structural engineers are planners and designers of buildings of all types: bridges, dams, power plants, supports for offshore projects, space programs, transmission towers, telescopes, and many other kinds of projects. Structural engineers analyze the forces that a structure must resist (its own weight, wind forces, temperature forces, earthquake forces, etc.), and develop the combination of appropriate materials which will withstand those factors. Wherever concrete, steel, aluminum, or other metals and materials are required to carry a load, structural engineers are responsible for the planning and design. They visit the construction site to make sure the work is done properly. Structural engineers usually work within a team that includes architects, mechanical and electrical engineers, contractors, owners of the project, bankers, lawyers, and officials of local government.

Hydraulic, waterway, irrigation, port, coastal, and ocean engineers deal with all aspects of the physical control of water. They analyze and predict water demands, supply and run-off. They work to prevent floods, to supply water for irrigation projects, to protect beaches, to manage and train rivers. They construct and maintain hydro-electric power systems, canals, lakes, port facilities and offshore structures.

Geotechnical engineers analyze the properties of soil and rock that support and affect the behavior of structures, pavements and underground facilities. They evaluate the settlements of buildings, the stability of slopes and fills, seepage of ground water and the effects of earthquakes. They take part in the design and construction of earth structures (dams, levees, etc.), foundations of buildings, and such structures as offshore platforms, tunnels, and dams.

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Environmental engineers design and supervise systems to provide safe drinking water and to prevent and control pollution in water, in air, on land, and in the groundwater. Their efforts are vital to many areas of water resource management, including the design of water treatment facilities, and the containment of hazardous wastes.

Transportation engineers are involved with the safe and efficient movement of both people and goods. They design and maintain all types of transportation facilities, including highways and streets, mass transit systems, railroads and airfields, ports and harbors. Transportation engineers apply technological knowledge as well as an understanding of the economic, political, and social factors in their projects. They work closely with urban planners, since the quality of the community is directly related to the quality of the transportation system.

The transportation of gas, oil, coal slurries, and commodities through pipelines has created another technical specialty, one which requires knowledge in geotechnical engineering and hydraulics as well as the structural properties of pipeline materials.

A wide-ranging specialization, construction engineering uses both technical and management skills to plan and build public and private projects and commercial developments. They apply knowledge of construction methods and equipment along with principles of planning, organizing and financing each job from start to finish, determining the equipment, plants, and men required. They estimate costs and monitor expenditures.

In urban and community planning, civil engineers are concerned with the full development of a community. They project street patterns, identify park and recreation areas, determine areas for industrial and residential growth, and act as consultants to airports and other related facilities. They coordinate the activities of just about everyone involved in a project, and in this role they must be people-oriented as well as technically knowledgeable.

Photogrammetry, surveying, and mapping engineers are involved in the precise measurement of the Earth's surface to obtain reliable information for location and for designing engineering projects.

To become a civil engineer you must of course attend college, and which college to choose is a big question. There are 190 institutions in the United States which offer accredited programs in civil engineering. The civil engineering programs at these colleges have much in common but vary in emphasis and detail. Most programs offered by these colleges are four- or five-year programs and consist of a curriculum of approximately one year of mathematics and basic sciences; one year of engineering science and analysis, one year of engineering theory and design; and one year that includes social sciences, humanities, communication, ethics and professionalism, along with electives which complement the overall education of the individual.

California Polytechnic State University, San Luis Obispo, civil engineering education emphasizes the study of engineering principles and the application of scientific

knowledge and technology for the betterment of mankind. The goal of the Civil Engineering Department is that the graduates of the program will be trained for the expanding needs of the society in transportation, structure, and environment under the broad Civil Engineering degree.

## APPENDIX

The *Employment Status Report 1983-84* is a report about all the graduated civil engineers of the 1983-84 school year. Cal Poly sent out a questionnaire near the end of 1984 and the statistics are taken from the returned questionnaires. Cal Poly had only fifty-four students graduate as civil engineers, forty-eight men and six women. Out of fifty-four graduates, thirty-three returned their questionnaires, twenty-nine men and four women. Their jobs range from teacher, a technician and a tool engineer, to a civil engineer. The salaries range from eight hundred and fifty dollars to three thousand six hundred dollars a month, with an average salary of one thousand nine hundred and eighty-two dollars a month. Even though they say jobs for engineers are scarce, these statistics show that most Cal Poly engineering graduates obtain jobs. They also reveal that salaries vary a great deal depending on one's specialization, where one works and for whom one works.

Once one has obtained one's C.E. degree one will want to become a professional civil engineer. To become a professional civil engineer one must complete the requirements for registration or licensure established by states and territories. Registration requires education, experience and successful completion of an exam conducted by an examining board.

The examination has two parts. The first part tests the basic and fundamental engineering knowledge of the applicant. This test is based on the average curriculum of all the departments of the engineering colleges. Young engineers are encouraged to take the first examination and obtain an Engineer-in-Training (EIT) certificate as soon after graduation as possible.

The second part of the test should be taken as soon as the minimum requirements for experience and age established by the state's board are met. In California, one must have five years of working experience to take the second part of the test.

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## THE DREAM OF A NATION

Alfredo Martinez

"We can follow our dreams to distant stars, living and working in space for peaceful economic and scientific gain. Tonight, I am directing NASA to develop a permanently manned Space Station and to do it within a decade."--President Ronald Reagan in the State of the Union Message, Jan. 5, 1984.

The clock is ticking. The President set the deadline: Do it within a decade.

The assignment: Develop a permanently manned Space Station.

The goal: Some 3,600 days from now, the United States will possess a permanent human-built island in orbit on which men and women can live and work.

### PAST HISTORY

The history of America's manned space program for the past two and a half decades has been built upon a series of logical steps. Man's first trips into space were short, daring feats made by men of unsurpassed skill and courage. They went into space for one reason--to determine if man could survive in its hostile environment.

Spurred by presidential direction that America should land a man on the moon and return him safely to the Earth, longer space flights were conducted to prove that man could perform the intricate maneuvers that would be required to achieve a lunar landing. Finally, the goal was reached. Man, for a short period, inhabited another heavenly body.

At the twilight of the moon-landing missions, America's space program came to a crossroad. It was time to chart a new course--a course that would demonstrate man could not only function effectively in space, but could exploit it for the benefit of all mankind as well.

Even before man took his first cautious steps into space, he had dreamed of a permanent outpost in orbit which could be used for observing the Earth and the heavens, or as a jumping off spot for missions to other planets and galaxies. America's first space station was called Skylab, a converted third stage of a left-over moon rocket. The modest orbiting laboratory was in space three months, proving that man could live and work in space.

The cost of getting to orbit was expensive. Apollo had been performed with costly, one-shot throwaway rockets. For space to be fully exploited, a vehicle had to be built that would make it easier to get to space, and cheaper to put things up there. The Space Shuttle was developed, and today teams of men and women travel into space regularly. They manufacture pure drugs and grow large crystals that could lead

to medical breakthroughs, and work with supercomputers. They study the Earth's land mass and oceans, and observe the stars and the planets.

People have accomplished much in the brief span of time since they first began exploring space, yet they have really only scratched the surface. More than a quarter century has passed since the first rocket was launched from Cape Canaveral, yet the actual time spent in orbit, experimenting and learning, has been but a fraction of that. The visits are too brief. A permanent facility in orbit is necessary to permit the long duration of time that work in space requires. A permanently manned Space Station is the next logical step.

In the State of the Union message, President Reagan announced a new, imaginative and far-reaching plan for America's space program, a plan that will carry the program well into the 21st century.

He directed NASA to develop a permanently manned Space Station and to do it within a decade.

The President's Space Station directive underscores a national commitment to maintaining United States leadership in space. Such leadership is essential, for America has become dependent upon operations in space for communications, resource analysis, and weather reports; for the conduct of science and the development of new technologies; and for the national security of our country. Space is no longer an unknown, unreachable environment. It is simply a place to conduct useful activities. A place for men and women to live, work, and learn.

Continued U.S. leadership in space is but one reason why a Space Station should be built. A Space Station will add significantly to knowledge of our own planet and the universe we live in. A Space Station will stimulate technology resulting in "spin-offs" that improve the quality of life for people everywhere. A Space Station will create jobs and maintain our nation's skilled industrial base. A Space Station will improve our country's competitive stance at a time when more high technology products are being purchased overseas. And a Space Station will be a source of pride for all Americans and a visible symbol of our nation's ability to carry out complex scientific and engineering endeavors.

#### WHAT EXACTLY IS A SPACE STATION?

The Space Station, as envisioned by NASA, will be a permanent, multipurpose facility in orbit. It will serve as a laboratory to conduct basic research, an observatory to look down at the Earth or peer out into the sky, a garage to fix and service other spacecraft, a manufacturing plant to make exotic metal alloys, superpure pharmaceuticals or perfect crystals, an assembly plant to build structures too large to fit in the Shuttle's cargo bay, and a storage warehouse to keep spare parts or even entire replacement satellites.

The Space Station concept provides for both manned and unmanned elements. The manned facility, as well as an unmanned free-flying platform, will be placed in a low Earth orbit of about 300 miles at an inclination to the equator of 28.5 degrees. Two

or more platforms in high inclination or polar orbits will be launched and serviced by the Space Shuttle.

The initial Station will support a crew of six to eight people with crew rotation and resupply from the Space Shuttle at approximately three-month intervals. In addition to living quarters, the facility will provide utilities (electrical power, thermal control, attitude control and data processing), work space, and a docking hub to allow tending by the Space Shuttle. The modules will be able to support scientific research and technology development requiring crew interaction.

The unmanned platforms will be able to provide changeable payload accommodations for activities requiring minimum disturbance and protection from contamination. A maximum of common subsystems such as power, thermal, docking, and data will be used both on the Space Station and the platforms. The co-orbiting platform will be tended and serviced from the Space Station. Modules will be designed and prefabricated on Earth. These will then be transported to orbit in the Shuttle's bus-size cargo bay. There, they will be unloaded and assembled by astronauts wearing space suits and propelling themselves with jet-powered backpacks.

While orbiting at an altitude of about 250 miles, these crews will use cranes and other tools designed especially for work in space.

One module will be furnished as living quarters for from six to eight persons; another module (or modules) will be outfitted as a combination workshop and laboratory. Environmental conditions inside the modules, resembling the interior of a passenger airplane cabin, will enable crews to work in Earthlike shirt-sleeve surroundings.

Other attached modules will carry utilities such as power generating machinery and still others will provide storage space for supplies and equipment. The Station will be self-sustaining for several weeks or even months. It will be partly independent from ground control. Crew members will have considerable discretion in their use of the facilities and in scheduling and carrying out their work.

Attached outside the modules will be platforms called pallets for automated and remote-controlled experiments and observation instruments. Other instruments will be carried on unattached free-flying platforms in separate orbits nearby.

These unmanned portions of the Space Station complex will be important for experiments and observation requiring protection from the contamination and vibration which are inevitably present in an inhabited spacecraft. These platforms are also necessary for maintenance, adjustments, repairs and retrieval.

At intervals of several weeks, the Space Shuttle will arrive at the Station to deliver a replacement crew and new supplies. Some or all of the old crew members will then return to Earth in the Shuttle.

## SCIENCE ACTIVITIES PLANNED

Among their numerous activities aboard the Station, crews will carry out basic research in medicine, astronomy, space physics and solar studies. They will conduct experiments in Earth sciences and in many other scientific disciplines. The crews will also work on technology experiments aimed at developing products and services useful for industrial customers and consumers.

Specially trained crew members will make Earth resources observations. Others will check out and launch automated spacecraft to higher orbits. Some crew members will provide in-orbit maintenance, repair and retrofit services for scientific and applications satellites.

One of the Space Station's crucial assignments will be to serve as a national laboratory. It is to be a center for the inception and development of the advanced technologies upon which our nation's economic and social well-being depends in an increasingly competitive and sophisticated world.

The intermittent visits of astronauts to Earth orbit will no longer suffice in the final years of this century, if our nation is to retain its preeminence in space. Sustaining America's competitive edge in technology, from which we derive our standard of living, requires continuing renewal and advancement. The Space Station will help us do this. It will become a key element in our nation's technological investment strategy as we approach the 21st century.

## SPACE ADAPTATION

Medical research will play an important role in the early phase of the Space Station era. Through research the industrialization of the later Space Station years will be made practical. For the time being, however, early medical research must concern itself with the "potentially serious" physical changes of the crew members repeatedly exposed to long-term periods of microgravity in order to prevent the occurrence of environment-induced occupational disease.

An issue of concern is adaptation vs acclimatization. Adaptation may be defined as that adaptive characteristic to an environment exhibited by living organisms through many generations of residence in a particular environment. Acclimatization is the process living organisms, that are adapted to a unique environment, use to adapt during exposure to a new environment which enables them to survive.

Understanding human adaptation to the Space Station environment and the implementation of appropriate medical research are a high priority. Previous space-flight experience indicates that microgravity can present some physiological changes to crewmembers in such areas as calcium homeostasis, cardiovascular adaptation, muscle atrophy, physical deconditioning, space motion sickness, drug pharmacodynamic changes, radiobiology, metabolic functions, environmental factors, red blood

cell alterations, fluid and electrolyte changes, immunological alterations, pulmonary function, oral health, and microbial contamination.

The state-of-the-art equipment on board the Human Research Facility (HRF) and the dedicated scientist-technicians will enable in-depth research which should produce statistically valid data on physiological adjustments of humans to microgravity. The goal of the research on board the HRF is to obtain a better definition of each problem and an understanding of the underlying mechanisms which will ultimately lead to prevention of the problems encountered by today's spaceflight participants.

### CONCLUSION

A challenging new era is under consideration and on its way. With it, come new problems and questions to solve and answer. Nevertheless, positive thinking is required of all those who participate in or share part of the Space Station's responsibility. Hence, no longer is space an unknown, unreachable environment. It is simply a place for men and women to live, work, and learn.

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## THE NATIONAL AERO-SPACE PLANE

Bruce Mendez

"Now leaving from gate 17, flight 392 to low Earth orbit." It may sound like something a long way off, but with the development of the National Aero-Space Plane, abbreviated NASP, that announcement may not be very far away. Utilizing advanced engine designs, like supersonic combustion ramjets, known as SCRAMJETS (shown in figure 1), and radical airframe configurations (figure 2), flights to low Earth orbit from conventional airports, and two-hour flights from New York to Japan, may be possible by the late 1990s to early 2000s. The SCRAMJET engine and airframe designs, required for the NASP to achieve these projections, will be made possible by supercomputers that can do up to 250,000,000 calculations per second. One such computer, the Cray 2, is now installed at the National Aeronautics and Space Administration's Ames Research Center.

The technology for this plane is not available yet, but it could be soon. Under the direction of the United States Air Force, companies are bidding on contracts to develop the technology for the NASP. The vehicle that will be developed to test this advanced technology was originally designated the X-31, but has been recently redesignated the X-30A. The reason for this redesignation is unknown to people outside of the Pentagon. It could suggest that the Air Force had previously been working on a similar aircraft, and had decided to combine the two programs into one. This design is now in Phase 2 of development and various companies will be bidding to design specific components of the vehicle, such as the engines and airframe. In April, 1986, the Defense Department and NASA awarded seven contracts to several aerospace companies for propulsion and airframe development over a 42-month period. Of the \$450 million worth of contracts, awards for propulsion, of about \$175 million each, went to General Electric (associating with Aerojet TechSystems), and Pratt & Whitney. Awards for airframes, of up to \$32 million each, went to Boeing, General Dynamics, Lockheed, McDonnell-Douglas, and Rockwell International. Based on present advanced engine work, Aerojet TechSystems will be associating with General Electric, but will not have a separate contract of their own, due to the Defense Department's preference to work with companies established in defense development. The many airframe contractors will be reduced to two or three by a design competition held during the first year of the contract period, to allow the best selection of the many possible design configurations. At the conclusion of the 42-month contract period designed to validate the applicability of the new high-risk technology required for the development of the NASP, the Air Force will begin Phase 3 by assuming the management of the program to develop a flight test vehicle. At the same time as the Air Force is developing a flight test bed, the research program sponsored jointly by the Defense Department and NASA will continue.

The technology to accomplish the tasks set for this new craft lies mainly in the development of the SCRAMJET engine. This engine allows air to enter at supersonic speeds before being mixed with the fuel and combusted to produce thrust. Currently, vehicles with supersonic capability utilize turbojets, ramjets, or a combination of both. Turbojets generally operate at subsonic speeds, and need a compressor to generate

the proper density and composition of air in their combustion chambers. To obtain supersonic velocity, turbojets often make use of an afterburner. Ramjets don't utilize a compressor, but need a high air speed to compress the air as it is rammed past the inlet, where fuel is injected directly into the flow. Compared to SCRAMJET engines, conventional engines operating at speeds above Mach 1 have to slow the air to subsonic velocity when entering the air inlet to allow the engine's compressor and/or fuel injector to work properly. This slows the exhaust velocity and ultimately the overall speed of the plane, and exposes several other problems. Air entering the inlet at high speeds exits the engine so quickly that conventional fuels don't have time to mix and combust before they are expelled out the rear of the jet. Additionally, the air heats the leading edge of the inlet to such high temperatures that current materials used in the design of aircraft, such as titanium, are unable to maintain their structural integrity. To overcome the fuel combustion problem, hydrogen or methane will be used, since their higher combustion rates will allow them to mix with the air and burn before it leaves the engine. Traditionally, heating problems have been overcome by using nickel alloys, but their high weight precludes any great use of these materials on aircraft. This problem may be solved by a DARPA-developed process called rapid solidification, combining the high temperature resistance of nickel alloys with the low weight of titanium. High speed flight through atmosphere also often causes the airflow through engine inlets to break down and become unpredictable. Variable geometry inlets, as shown in figure 2, alleviate this problem by changing shape to better direct the airflow as the craft reaches higher speeds.

Many different airframe configurations are being considered for the Aero-Space Plane. Currently, there are probably over a dozen designs being looked at for the optimal performance of the plane, and the media are littered with them. Several are based on the lifting body principle, which was well tested during the military's experimental aircraft program, now revived with the X-29 and X-30A. Lifting bodies use the shape of their hull, instead of wings, to generate lift. Other designs are similar to the abandoned Super Sonic Transport, or SST; canceled because of public pressure. The SST design was criticized for being too noisy; something that will not be a problem with the NASP, since it flies at such high altitudes. Still other designs resemble nothing currently in the air, or on the drawing boards. These may be the designs most likely to be chosen, because, with the radical new engine designs, current airframe concepts just can't be adapted to the requirements demanded of them. One such design is the British concept called HOTOL, for Horizontal Take Off and Landing. The HOTOL has small wings located far aft along the fuselage, canards, and an air intake slung beneath the body of the craft at the rear. Another major difference is that the fuel tanks are located in the body of the craft, rather than in the wings, taking up all of the interior space not used for payload, avionics, or engines.

The National Aero-Space Plane is an extremely versatile and adaptable aircraft. It can be developed into an Orient Express that would dramatically improve trade with countries in Asia and elsewhere; a commuter transport to ferry men and materials to space, an advanced tactical fighter or bomber, and an unparalleled high altitude spy-plane to observe troubled spots all over the globe. Utilizing the technology developed by this pilot program, it will be possible to quickly and easily get to low-Earth-orbit, go halfway around the world in a fraction of the time it previously took, and lead

the world in the development of advanced technology to improve our lives and the lives of many others.

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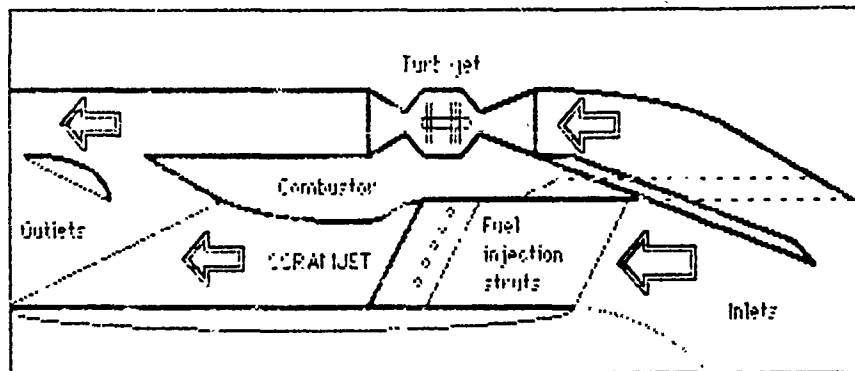


Figure 1.- Combined turbojet/SCRAMJET engine.

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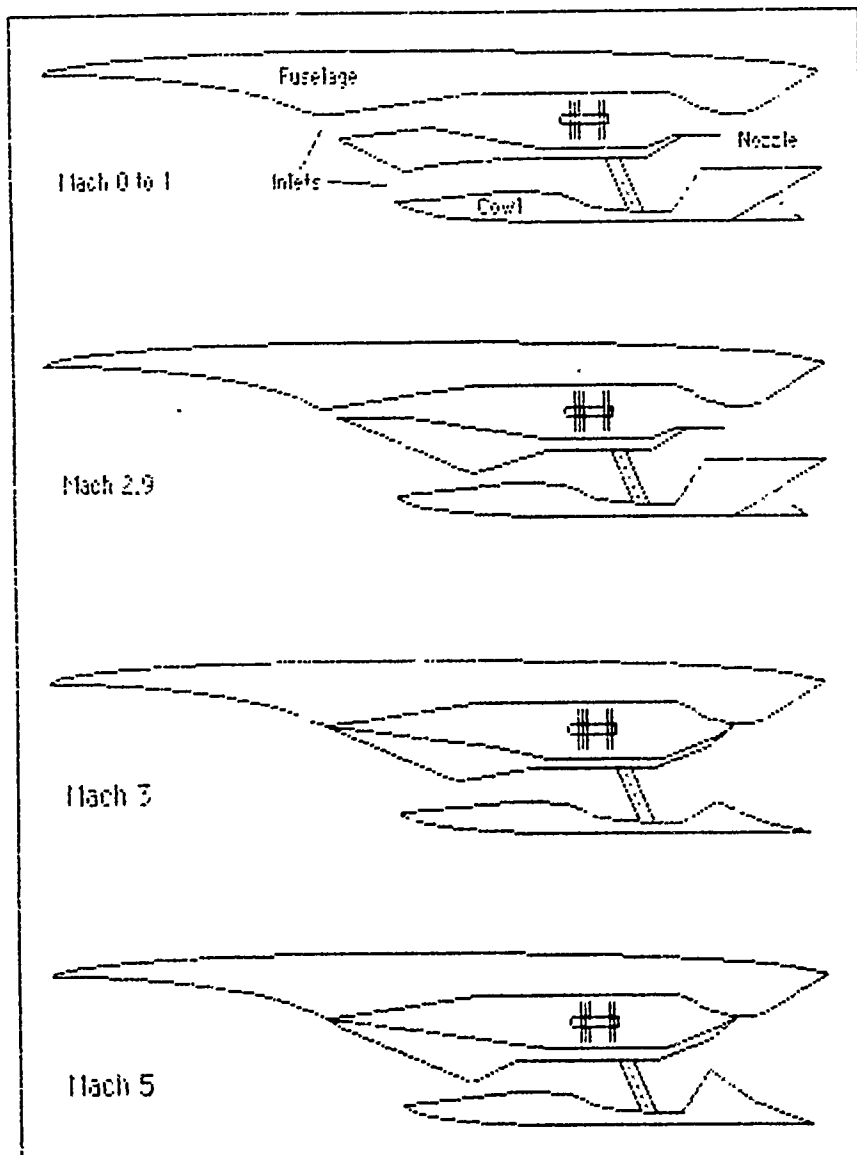


Figure 2.- Variable geometry engine design.

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## THE WIND TUNNELS OF THE NATIONAL FULL-SCALE AERODYNAMICS COMPLEX 7P

John Moon

As aviation becomes increasingly advanced, wind tunnels are playing a more important role in the development of modern aircraft. The first studies of flight were focused on birds, and as a result, the first aircraft were built with bird-like structures. After years of failure, scientists realized that they knew little about lift and drag forces acting upon aircraft surfaces (aerodynamics). Thus, laboratories with controlled conditions were built to test wings, fuselages, and other surfaces on the aircraft. The principle behind the wind tunnel was very simple; one could either move the model through still air or let the air move past the stationary model. The latter choice, being more feasible, was used in building wind tunnels. Interestingly enough, the first wind tunnel was built 30 years before the flight at Kitty Hawk.

Today, there are many wind tunnels in use by government agencies, private industries, and major universities around the world. Two of the largest wind tunnels in the world are located at the NASA Ames Research Center in Mountain View, California. The 40- by 80-Foot Wind Tunnel in combination with the 80- by 120-Foot Tunnel is referred to as the National Full-Scale Aerodynamics Complex (NFAC).

The 40- by 80-Foot Wind Tunnel, named after the dimensions of its test section, was built during World War II by NACA engineers at Ames. NASA was originally called NACA (The National Advisory Committee for Aeronautics). Construction began in 1942 and was completed in 1944. The sole bid on the tunnel of \$6,164,000 was made by the Pittsburgh-Des Moines Steel Company. The project ended up costing NACA about seven million dollars. Design and construction was supervised by Dr. Smith J. DeFrance, former director of Ames. The test section is 50 feet above ground and test models are lowered into the test area through the doors on the top of the tunnel.

The 40- by 80-Foot Wind Tunnel was the first full-scale wind tunnel to be built. Its six 40-foot-diameter fans, each powered by a 22,500-horsepower electric motor, produce test section airflow up to 330 mph. The extremely large size of the test section enables the testing of very large models, actual flight vehicles, and structures influenced by airflow, allowing closer simulation of actual flight. This tunnel became the primary facility for studying the flying characteristics of helicopters and vertical takeoff and landing (VTOL) aircraft. The tunnel tests examined the critical flight regime of the VTOL where the craft makes the transition from vertical takeoff to forward flight. The tunnel also helped study the structural failures of advanced helicopter rotors and new VTOL aircraft. With the use of well-instrumented tests, the causes of failure were easily found, leading to proper modifications.

The 80- by 120-Foot Wind Tunnel of the NFAC is one of the largest wind tunnels in the world. It is directly connected with the 40- by 80-Foot Wind Tunnel and shares the same fan drive system. This tunnel can produce top test section airflow speed of about 115 mph. Construction began in the late 1970s and owing to an unexpected

incident the tunnel is still undergoing construction and modifications. The new tunnel will be an addition of a 600 foot-long leg extending northwest from the west side of the 40- by 80-Foot structure. Airflow through the new leg will enter through the intake at the end of the leg and flow through the test and drive sections. Then the exhaust will go through the vanes attached to the 40- by 80-Foot Tunnel. The total cost of this tunnel is expected to be over \$85 million. The enormity of the test section will enable engineers to test real aircraft for their landing and takeoff characteristics. Because all aircraft must land and take off at low speeds, this large, low-speed wind tunnel should be useful far into the future.

The two tunnels of the NFAC are of two different types. The 40- by 80-Foot Wind Tunnel is a closed return wind tunnel (Gottingen type) with a half-mile-long circuit, whereas the 80- by 120-Foot Wind Tunnel is an open circuit tunnel (Eiffel type). A closed return tunnel is shaped in a circuit so that it has a continuous flow of air in a circular pattern. An open circuit tunnel, on the other hand, is a type of tunnel where the flow of air follows a straight path from the entrance through the test section, followed by the diffuser, a fan section, and an exhaust of the air. Although different, the two tunnels share the same drive system.

Both types of tunnels have their advantages and disadvantages. One major advantage of a closed return tunnel is that it requires less energy to operate than the open circuit wind tunnel. Moreover, there is less noise during operation. An open circuit tunnel, however, costs less to build because it doesn't need return ducts and corner vanes to recirculate the airflow.

The basic design of the NFAC wind tunnels is a subsonic tunnel built to test takeoff and landing qualities of aircraft. A major part of the wind tunnel is the fan drive system. The NFAC tunnels both share one fan system currently capable of 135,000 horsepower. This system is comprised of six 15-bladed fans that are 40 feet in diameter. Each wooden propeller is driven by a 22,500 horsepower electric motor. At full speed, the motors reach 180 rpm. As in most wind tunnels the fans on the NFAC tunnels are located downstream of the second corner because highest efficiency is developed at this position. Airflow is created by having a low pressure area in front of the test section and a high pressure area behind it. The motors for these fans are mounted in the nacelle, an aerodynamic casing for the motor attached to the fan. In order to cool the motor, cooling air is blown through the nacelle supports and into the nacelle itself. As the fans circulate the airflow, turning vanes guide the flow around corners with a 90 degree bend. In addition, the turning vanes were added to avoid significant losses of airflow. Usually these corners are separated by a short duct. The first two corners of a closed-circuit tunnel are the most critical because of the uniform velocity of airflow needed at the fan.

The test sections of the NFAC tunnels are 40 by 80 feet and 80 by 120 feet as suggested by their names. The smaller tunnel has an elliptical-shaped test section whereas the larger tunnel has a rectangular test section. The test section of a wind tunnel is obviously the most crucial section of the tunnel, because the aircraft is placed in this section and all activities go on in this place. Models are brought into the test sections through huge doors by using a crane system. The 40- by 80-Foot Tunnel has its doors on the top of the test section, and the models are lowered into the test area.

The larger 80- by 120-Foot Tunnel has two large doors located on the east side of the tunnel test section. For this tunnel a 75-ton-capacity gantry crane is used for transporting models to and from the test section.

Both tunnels have a similar model support system. In the centers of the test sections, there are three struts mounted on a turntable. These struts can be adjusted to accommodate different models. Different angles of pitch or yaw can be tested and analyzed. The turntable which holds the struts is mounted to the wind tunnel balance. This balance, located below the test section, records the different forces applied to the model by the use of levers. There are several scales to measure lift, rear lift, drag force, and side force; the scales are very accurate. For example, in the 40- by 80-Foot Tunnel the accuracy of its balance system ranges from 0.01% of full scale for lift to 0.09% of full scale for pitch moment.

One difference between the two tunnels is the acoustic equipment in the test sections. The 40- by 80-Foot is lined with six inches of sound-absorbing material because it is used to test jet-powered models and helicopters with rotors turning. The 80- by 120-Foot has no acoustic materials lining the test section walls which are made of sheet metal. Both tunnels are controlled by way of the control room located outside the tunnels. An array of monitors and other instrumentation can be found in the control room.

The National Full-Scale Aerodynamics Complex consists not only of the wind tunnels but also three branches comprised of many engineers, computer programmers, technicians, etc. Currently, there are three branches--Fixed Wing Aerodynamics (FFF), Rotary Wing Aeromechanics (FFR), and Research Operations Branch (FFN). These three branches are in charge of testing, maintaining, and operating the complex. The Fixed Wing Aerodynamics branch consists mainly of aeronautical engineers studying all aspects of fixed-wing atmospheric aircraft. This is done through testing fixed-wing aircraft in the wind tunnels. They are also involved in researching and testing experimental aircraft such as Forward Swept Wing planes. The Rotary Wing branch is involved more with rotorcraft than with fixed-wing planes. This branch studies different types of rotors and their aerodynamic characteristics. The third branch, Research Operations, is responsible for maintaining and operating the wind tunnels in the NFAC.

Testing models and actual aircraft is an integral part of the NFAC engineers' work. The 80- by 120-Foot Tunnel has never been in operation, so no testing has been done in that facility, but there have been over 500 tests done in the 40- by 80-Foot Tunnel ever since its completion in 1944. The first tests done in the tunnel were mainly defense related. Some aircraft tested in the tunnels are the F-84 Thunderjet, Douglas XSBD-2, and a couple of years ago a model of the Space Shuttle was tested in the tunnel to study its aerodynamic characteristics. Also, many fighter-bombers and helicopters have been tested there.

On December 9, 1982, a major accident occurred in the wind tunnel causing it to be shut down for almost four years. The accident occurred during a test of the new 80- by 120-foot test section when a set of diverter vanes failed, and pieces of the steel-covered wooden vanes were pulled into the fan drive system destroying most of the

fan blades and scattering debris throughout the fan diffuser area. The system was running at 107 mph when the vanes failed causing a vacuum effect in the tunnel. Tests done earlier at similar speeds in the 40- by 80-Foot Tunnel showed no signs of any problems in the vanes, but the vanes did not divert the flow of air as they experienced a greater load when the larger test section was in use. The damage was about \$35 million, most of which went into research, turning vanes and purchasing new fan blades. Luckily no one was injured in the accident.

The accident also caused problems with the testing schedule for Ames. Among the programs affected were the Grumman 698 tilt-nacelle vertical/short takeoff and landing (V/STOL) aircraft model, V/STOL fighter configurations, and a forward-swept wing aircraft model. The schedule had to be rearranged so work in the big tunnel could come later.

The incident, which took place in 1982, has greatly set back Ames' aerodynamics research, but the NFAC will be ready for operation early this fall after years of repair and modifications. New systems have been installed to monitor the wind tunnels better, so that no mishaps like that in 1982 will ever happen again. Many of the workers involved with the wind tunnels are eager to see them running again. The first aircraft to be tested in both wind tunnels will be the Grumman 698 V/STOL aircraft. Before any aircraft testing starts the two tunnels will undergo a thorough systems check. If all goes well the NFAC wind tunnels should play an important role in the future of aerodynamics.

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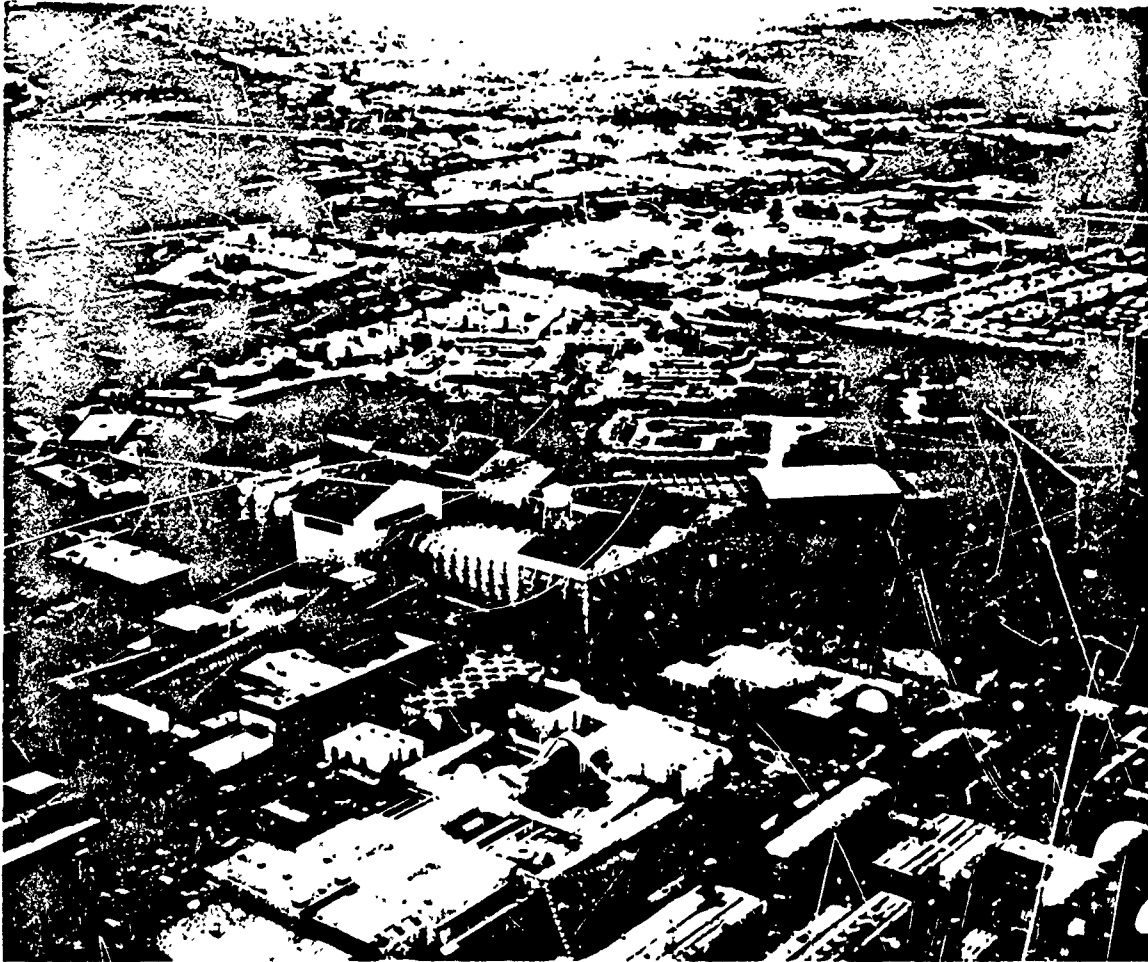


Figure 1.- The NFAC complex is a dominating structure at NASA Ames. The 80- by 120-Foot Wind Tunnel can be seen on the right extending from the 40- by 80-Foot Tunnel.

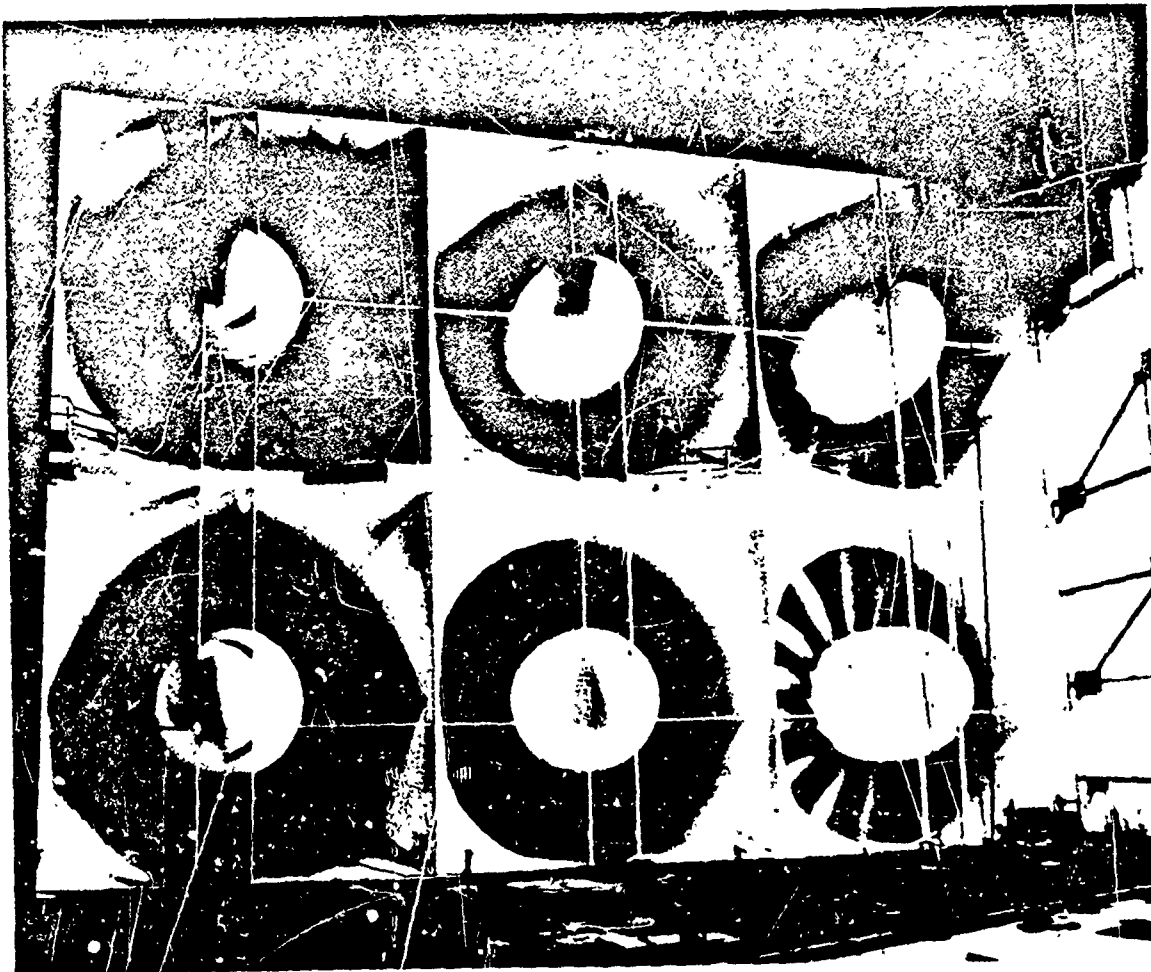


Figure 2.- The drive system consists of six 15-bladed fans each powered by a 22,500 horsepower electric motor.

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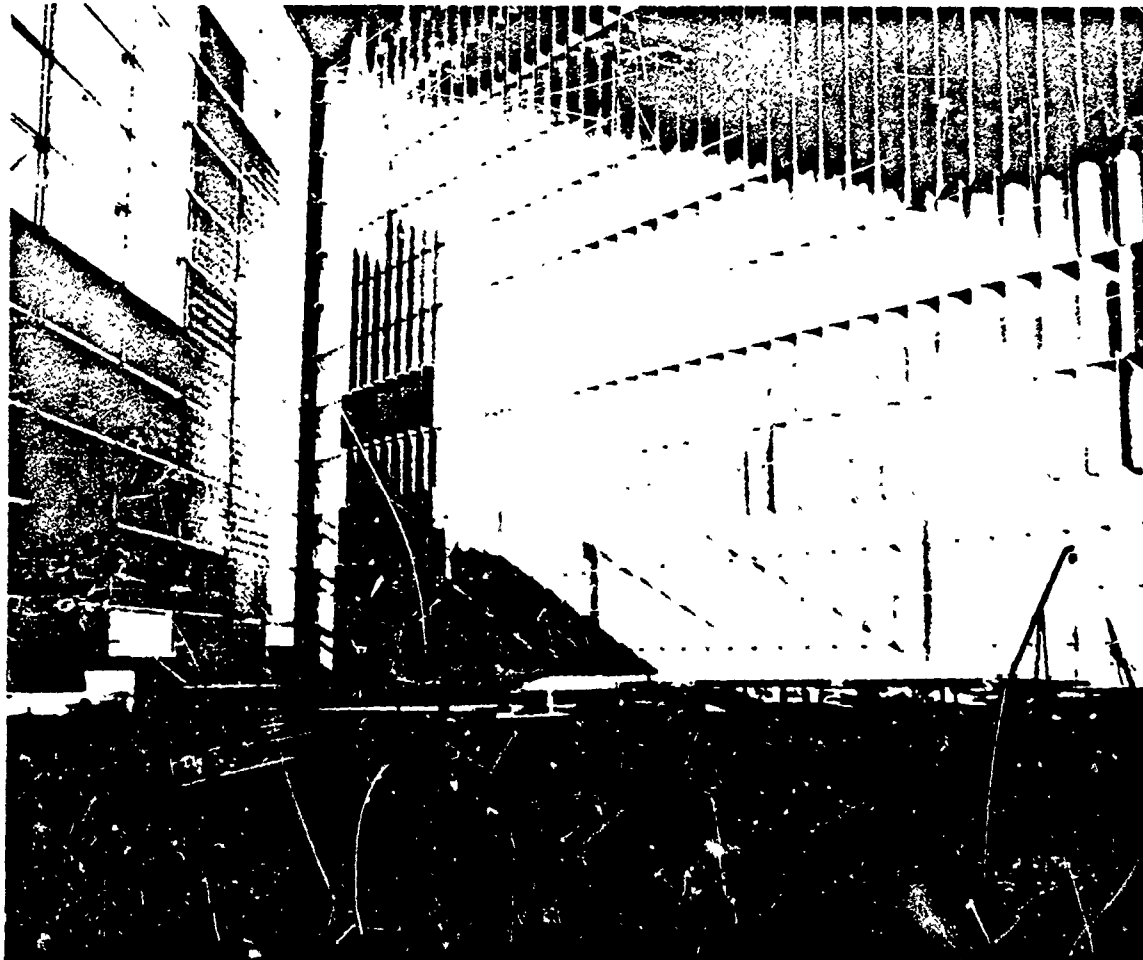


Figure 3.- Diverter vanes are used to direct the airflow around the corners of the 40- by 80-Foot Wind Tunnel.

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## THE SPACE STATION

Abraham Munoz

Conceived since the beginning of time, living in space is no longer a dream but rather a very near reality. In times and civilizations past man could only dream of the vastness of space. No longer is man restricted to land and sea, he has found a new frontier to extend himself to. In his quest to explore this new realm, man must possess the greatest of knowledge and use it well. Although much time will elapse, space will succumb to another master.

America's space program rose from an advisory committee, National Advisory Commission on Aeronautics, to a supreme aerospace organization, National Aeronautics and Space Administration. Many great projects and moments are now under America's belt, but many more are yet to come. NASA's newest challenge was well described by our great president, Ronald Reagan, in his State of the Union Message on January 5, 1984.

We can follow our dreams to distant stars, living and working in space for peaceful economic and scientific gain. Tonight, I am directing NASA to develop a permanently manned Space Station and to do it within a decade.

A Space Station will permit quantum leaps in our research in science, communications and in metals and life-saving medicines which can be manufactured only in space.

This conception is not a new one, but a redefined one. In the early seventies Skylab represented an early and successful configuration of space stations to come. NASA learned a great deal from this project. Much of what it learned, ranging from human behavior in space to experiments in space, will be very useful to this next generation of space stations.

In order to meet its deadline of ten years (although it's hoping to do the job in eight years in commemoration of Columbus' 500th anniversary of the discovery of the New World) NASA and its contractors are constantly working to develop the design of the Space Station that is due sometime in 1987. Many investigations on the kinds of experiments and work assignments the Space Station will need to accommodate have been completed, but NASA specialists are constantly talking with potential users of the Station to learn more about the work they, the users, want to do in space.

As presently proposed, the core of the Space Station will consist of six or seven modules, cylinders of approximately 14 ft in diameter by 24 ft long (see figure 1). One of these modules will be used by the European Space Agency, ESA, and another by Japan. The remainder, of course, will be used by the United States. They will be designed and arranged so that newer and more sophisticated modules can be added in the future. The Space Station will grow as its importance grows. Each module will

be pressurized to a normal human level and will contain its supply of necessary oxygen. They will be connected by hubs (see figure 1). These hubs will permit easy mobility between modules and are the connection areas for future modules.

One of these modules will house the crew on board the Station. Separate living quarters will be provided for each astronaut. Although astronauts don't need beds in space, for they float in zero-gravity, they do need straps to hold them in place. They will substitute vertical sleeping bags for the regular horizontal beds. These quarters will be private and personal areas for the astronauts to retreat to. Designed to serve as a home away from home, the Space Station will be a home to between six and eight people. Each crew will be in space for approximately 90 days. At the end of the 90 days a new crew will come up from Earth on the shuttle to replace the previous crew. Within each crew half of the members will work one shift while the other half sleeps. This rotation system will allow for more room, around the clock personnel, and less fatigue on the station. From past experience, data taken from Skylab and information released from the Soviet space stations Salyut and Mir, it has been obvious that workers in space become homesick. They miss their families, friends, food, sights, and sounds which they were accustomed to on Earth. In order to solve this problem, personal photos and items are to be allowed in each crew member's sleeping quarters. Daily phone calls to family members will be available. Because bird chirping, the blowing of wind and other natural sounds are obvious Earth sounds, they are being proposed to be played on board the station at a subliminal level so they can be picked up by the subconscious mind, thus creating an artificial Earth-sounding environment. Viewing our planet, as told by former astronauts, is such a spirit-lifting experience that windows will be strategically placed to provide this pleasure. Providing a home-like atmosphere for people in space will increase morale and productivity.

Two other modules are scientific laboratories. They will be used to carry out experiments which can only be done in space or experiments which benefit from zero-gravity. In these labs basic research in medicine, astronomy, space physics and other fields will be carried out. These studies will be aimed at developing useful services and products for industrial customers and users. These labs will serve as national laboratories upon which our nation can depend for economic and social well-being in an increasingly competitive and sophisticated world. Another module will serve as a logistics unit, primarily a supply module. All necessary supplies required for a three-month stay in space will be kept here. This will keep the other modules free from any supplies that shouldn't be there. One other module will serve as a berthing dock for the Space Shuttle. Being that the shuttle is the only transportation vehicle between the Space Station and Earth there must be an area in which to park the shuttle. It will be through the Space Shuttle that the new crews and supplies will be brought up at the end of each three-month period. In case of an emergency the shuttle will be sent to respond to the incident. Also in one of these modules a kitchen and an exercise room will be located.

These modules will be connected to large trusses (see figure 1). Extending away from the modules will be two sets of large solar panels which will generate enough energy from the sun to provide the necessary power for the entire complex. Gliding along the trusses will be a remote controlled robot arm. This manipulation unit will allow for easy on-board repairs of the station and quick structure relocations.

Although much of the work which will be done on the station will be directed by the crew itself, continual communication linkage between ground control and the station is required. A dish antenna on the station will connect both parties.

Each part of the Space Station will be carried separately on the space shuttles. Then as each part arrives in space it will be connected to the previous structure which is already in space. The trusses and solar panels will be the first items to be launched. During the fifth or sixth shuttle launch the first module is expected to go up. The module will go up as a single unit so that it can easily be connected to the other structures already intact. It is during these next few launches that the Space Station will become habitable by our astronauts. The remaining parts of the Space Station will continue to go up as soon as possible and on schedule if all goes well. Between 14 and 17 launches are expected in order to complete the station which will be 250 miles above the Earth's equator.

Once the station becomes operational America will begin to reap the harvest of its work. Space does not limit itself to one field. Commercial uses in space are limitless. First and foremost, many satellites near low-Earth orbit will be in need of repair. Using the Manned Maneuvering Units, MMUs, astronauts from the Space Station can easily repair the satellites. The cost to the customer will be substantially less than if he were to have replaced the satellite. Also, the space telescope, which is planned to be launched as soon as the Space Shuttle becomes operational, will need tending. Much knowledge about deep space will be gathered from this instrument, and for this reason it must be kept operational at all times. The research being done on the Space Station cannot be put aside. This research will greatly aid those people, industry, who invest in it. This in turn will benefit our entire society.

As important as the research going on in space, will be the future manned and unmanned voyages which will use the Space Station as a port. From here the United States of America can commence plans for building a lunar base. All the necessary material would be sent to the station and from there on to the moon. A lunar base has many uses and will benefit from having the Space Station at its disposal. During this same time period, between 2000-2010, a manned mission to Mars would become more attractive. By assembling the spacecraft in orbit and launching it there, it will not need to be equipped for a strenuous passage through the Earth's atmosphere. Instead, it can be constructed entirely for use in the vacuum of space with resulting design and economical advantages. The trip to Mars and a Martian base would be mankind's next giant leap in his quest to increase his knowledge of the universe.

Maintaining U.S. Leadership in space, studying the Earth's resources, developing new manufacturing and processing techniques, basic science and technology research, and becoming a port for future interplanetary voyages is the purpose of this eight billion dollar Space Station. For 20 years after it's completed (this is the life expectancy of the station) the Space Station will serve as a symbol of national pride and honor. It will kindle our imagination and creativity. It will inspire America's youth to reach for greater achievements, and hopefully will inspire them to seek professions in space-related fields. Within those 20 years the Space Station may become obsolete as a better breed of space stations emerges. But one thing remains for certain,

and that's that this Space Station will be the Pinta, the Nina, and the Santa Maria embarking on a trip to explore the new world of space.

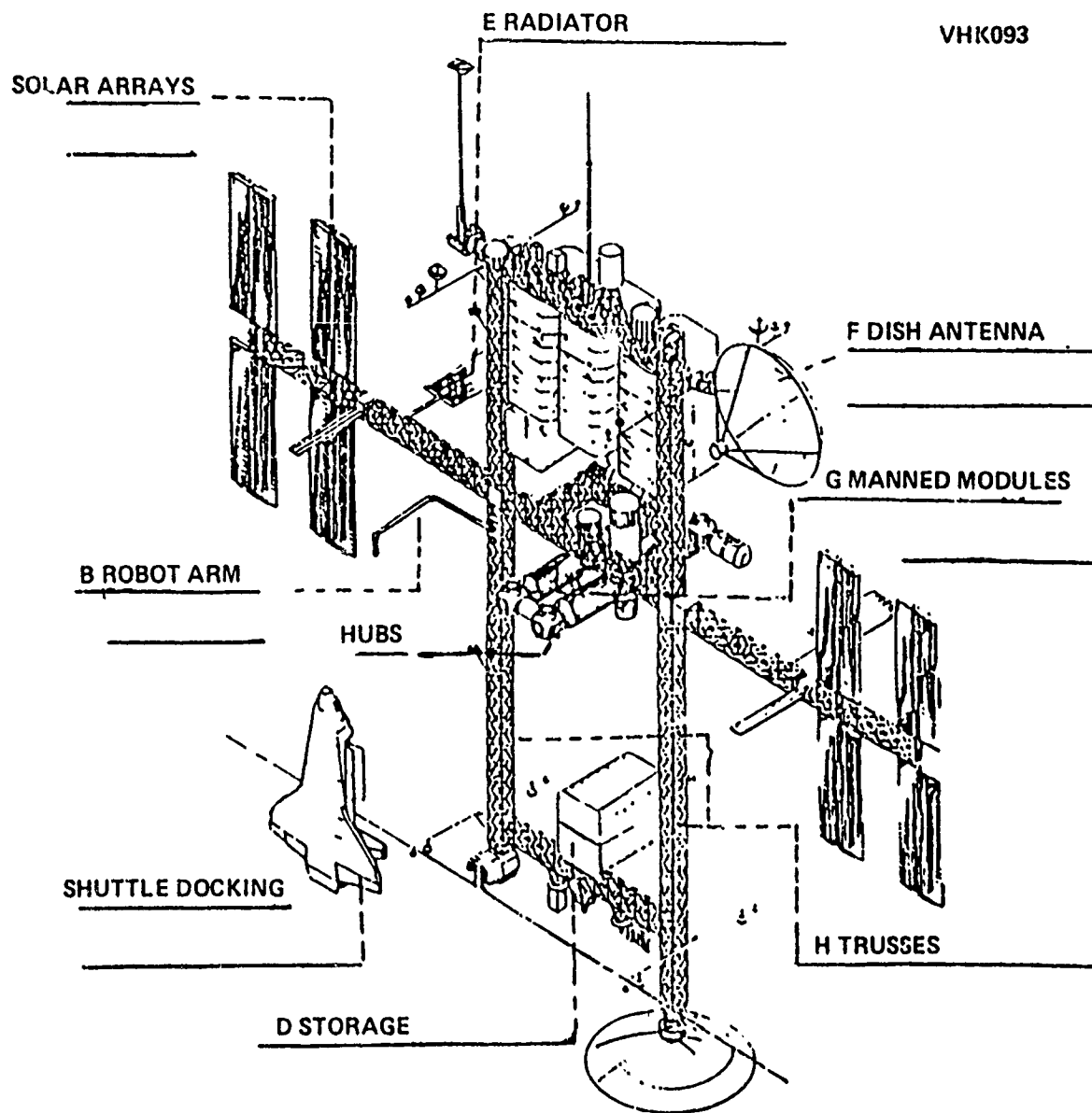


Figure 1.- Features of the Space Station.

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## CRYOGENIC MIRROR ANALYSIS

S. Nagy

### 1. INTRODUCTION

Due to extraordinary distances scanned by modern telescopes, optical surfaces in such telescopes must be manufactured to unimaginable standards of perfection of a few thousandths of a centimeter. Upon what seems a perfectly ground and polished mirror, there will lie ripples, bumps, valleys, and a variety of aberrations and distortions. To detect these imperfections requires an intricately tuned optical system in conjunction with a phase-shift interferometer. The goal of the Astrophysical Experiments Branch group at NASA Ames was to be able to detect imperfections of less than  $1/20$  of a wavelength of light, for application in the building of the mirror for the Space Infrared Telescope Facility (SIRTF). Because the mirror must be kept very cold while in space, another factor comes into effect: cryogenics.

Cryogenics refers to very cold liquids or surfaces, such as liquid helium (4.2 Kelvin). Since the mirror that will be used in SIRTF must detect radiation in the infrared range, any stray radiation from the telescope facility would degrade the quality of the image received from outer space. For this reason, the mirror must be cleverly surrounded by various heat-shields of liquid helium, liquid nitrogen, and reflective coatings. But like any other surface that is cooled, the mirror will bend and twist out of its normal shape. This results in erroneous images.

How does the mirror become distorted? Is there any way to correct its aberrations, so as to receive a clear image? How does the light energy reflect from a warped mirror? These are some of the questions that are being answered by Cryogenic Mirror Testing/Analysis. This paper describes the process to test a specific mirror under cryogenic conditions; including the follow-up analysis accomplished through computer work. To better illustrate the process and analysis, we will follow a Pyrex Hex-Core mirror (Photo 5) through the process (referring to it as Mirror 1A) from the laser interferometry in the lab, to computer analysis via a computer program called FRINGE.

FRINGE has been an integral part of the Cryogenic Mirror Analysis giving Ames Research Center a fairly advanced computational tool for the analysis of an interferogram (an image describing the characteristics of an optical surface), which is vital to SIRTF. FRINGE has served as a solution to the problem of quantifying test data so that surface profile and other optical characteristics can be quantitatively determined.

The program can be viewed as a collection of subroutines that the user can arrange to quantify a variety of test data and reduce it such that a high quality optical path difference (OPD) map is produced. With this map, other analysis subroutines can be used to test optic errors, perform image quality analyses, calculate aberration coefficients, determine residual errors, etc. (Taken from *FRINGE manual*, Arizona Optical Sciences Center)

## 2. MECHANICS OF THE ANALYSIS PROCESS

During this discussion of the lab set-up and procedure, refer to the diagrams and pictures in Appendix A and Appendix C, respectively. For analysis of how the mirror will perform under extreme cold conditions, it is first mounted to the bottom of the top section of the dewar assembly as seen in Photo 4. The mirror must be firmly and precisely mounted to avoid wobbling. The dewar assembly, as seen in Photo 3, is the apparatus by which the mirror can be cooled to nearly 4 Kelvin (liquid helium temperature) to simulate its environment in space. Diagram 1 is a section view of the entire dewar assembly as seen in Photo 3.

Once the test mirror has been attached, the bottom two components of the dewar are attached, and the cooling down process begins. The liquid helium and the liquid nitrogen tanks at the top of the dewar are filled, after the air is pumped out from between the walls of the dewar. The laser interferometer, Photo 2 and Diagram 2, has been turned on at this point and during the cooling of the mirror, the laser is manually kept the correct distance from the mirror to remain in focus, by use of a micrometer mount (on Diagram 2).

Carbon resistors placed on the mirror surface and the walls of the dewar, indicate the temperature. As the temperature approaches that of liquid helium (4.2 Kelvin), the interferometer is precisely focused so that a clear image exists. The path of the laser beam is as follows. (Refer to Diagram 2.) First the laser beam, generated by a Helium-Neon Laser, passes through an aperture to filter out any scatter radiation or fuzziness. Then the beam passes through a microscope objective, which concentrates and narrows the beam, toward a beam-splitter cube where the majority of the light is reflected upward toward the test mirror through a window opening in the bottom of the dewar assembly.

Let us imagine that the light travels upward toward the mirror in small packages. Upon reaching the mirror, the light is reflected. Note that the light, however, may not be returning along the same path as when it was traveling toward the mirror, because the mirror may be warped from the cryogenic conditions. The reflected package of light meets with one of the packages of light that have been reflected downward by the beam-splitter cube. Ideally, the two packages should coincide, but because the reflected package of light is distorted, the two packages do not always mesh. In the areas where they do not mesh, they neutralize each other. This is called destructive interference, thus producing dark lines on the interferogram (Photo 1). These streaks are named fringes.

The light zones are where the two packages of light did not cancel each other. Once the fringe pattern is in focus, a photograph is taken. This is the point at which the fringe analysis via computer begins.

Photographs taken in the laboratory of the interference fringe pattern are digitized by an Apple IIe and HiPad digitizing tablet. The photo is placed on the tablet, where the fringe lines are manually entered into the computer, fringe by fringe until the image on the computer screen resembles the pattern on the photograph. At this point,

the computer converts the digitized coordinates into three-digit x/y coordinates (inch measurements without the decimal point). A hard copy of these coordinates is then generated for manual data entry into the VAX mainframe computer via a Tektronix terminal.

The digitized x/y coordinates of the fringe pattern are entered into the VAX as a file, each line having the x/y coordinates for a certain fringe. Various options are open to the user, depending on the type of mirror being used and the type of output desired. The following commands initiate the setting of parameters that can affect the output from the FRINGE program:

- a. WEDGE: specifies the frequency of fringes to be scanned
- b. COBS n: n is the fraction of the mirror radius represented by the hole
- c. STEP: defines the contour interval for the contour map (fraction of wavelengths)
- d. WIDTH: defines the fraction of the contour interval in which the characters will be printed, ranging from 0 to 1 where 0 will print characters only when they are identical to the contour value; a width of 1 will print characters at every position and the map will be filled with print (see RESULTS AND WHAT THEY MEAN, Contour Map).

### 3. RESULTS AND WHAT THEY MEAN

Once the data have been entered and the parameters have been set, FRINGE is run. A typical hard copy of the results from the calculations is included in Appendix B. Some of the important pieces of information are:

- a. STREHL RATIO: a measure of how close the mirror is to the ideal, with 1 being the ideal; defined as: given  $r = \text{RMS Surface Error}$
- b. RMS SURFACE ERROR: root of the means of the squares of the Zernike polynomial coefficients; defined as:
- c. CONTOUR MAP: a top view of the mirror surface showing the peaks and valleys, much like a topographic map, using the letters A-N for decreasing mirror surface, and the letters P-Z for increasing mirror surface
- d. ZERNIKE POLYNOMIAL COEFFICIENTS: the terms of an endless series (truncated to 36 terms for practical purposes) that represents the aberrations found on the mirror surface

In addition to alphanumeric output, we have the option to generate color graphic plots. They are RED, GSPOT, and 3D Plot of Aberrations, as found in Appendix D. All of these plots have been created from the Zernike polynomial coefficients calculated on Mirror 1A. Refer to the first set of plots (Group I) in Appendix D during the discussion of the three different types of plots. They represent general plots of all the contributions obtained from Mirror 1A.

The first plot, 1A, describes the physical topography of the mirror surface in an exaggerated fashion. It provides for a visual understanding as to how all the aberrations combine to distort the mirror surface. Subsequently, the aberrations that combine to create the mirror surface, can be broken down, isolated, and categorized as being one of the following: Radial (Spherical),  $1\theta$  (Coma),  $2\theta$  (Astigmatism),  $3\theta$ ,  $4\theta$ , and  $5\theta$ . We will look at all the distortions of Mirror 1A, except  $5\theta$  because of its negligible contribution in this case.

Plot IB is referred to as GSPOT (Geometric Spot Diagram), which is the result of a Geometric Ray Analysis showing the intersection of approximately 640 rays with the image plane and as a radial energy distribution function.

The last type of plot, the Radial Energy Distribution plot (RED) depicts the energy concentration percentage at a given radius from the center of the mirror. This is the energy that is reflected back from the mirror. Notice on Plot IC the sudden decline of energy between 0.00 and 0.80. This is due to the COBS parameter which defines the mirror as having a central hole. Therefore, no energy is reflected in that region.

The Radial Contributions, Group II plots, reflect a wave-like distortion from the center out. Thus the name spherical. The distortion is symmetrical, as is evident from the 3D plot, and from the GSPOT diagram. Also note the slight dip in the rise of the Radial Energy Curve. This is also a result of the undulations present on the mirror surface. The Group III plots show the characteristics of Coma distortion, which is quite minimal in this instance as seen from Plot IIIA.

The  $2\theta$  and  $3\theta$  Contribution plots are similar in that they both characterize a "potato chip-like" aberration in which there are distinct, symmetrical highs and lows. Note that the  $2\theta$  has only two highs and two lows, whereas the  $3\theta$  has three highs and three lows. And lastly, the  $4\theta$  Contribution, Group IV, which lacks a very significant contribution.

#### 4. THE FUTURE OF CRYOGENIC MIRROR ANALYSIS AT NASA AMES

Through Cryogenic Mirror Analysis, the SIRTf group at Ames has been able to study the way different mirrors distort under extreme cold conditions. Beryllium, glass, and pyrex mirrors of different shapes and sizes have been tested. The next step, yet untested, is to try to reconfigure a mirror in an optical manufacturing environment so that it will be an undistorted mirror at cryogenic temperatures. This can be accomplished by polishing the mirror at room temperature using the data acquired from cryogenic testing. Where a peak existed at cryogenic temperature, a valley would be pol-

ished at room temperature. And vice versa. Then, theoretically, when the mirror is cooled it would distort from a bad mirror surface at room temperature, to a perfect surface at cryogenic temperature. This is what remains to be discovered through intensive testing.

In addition to the next steps in mirror reconfiguration, a few lab improvements are being sought. Plans for a larger dewar to accommodate larger mirrors are in sight as well as the purchase of a real-time, phase-shift laser interferometry system that would increase the present accuracy of 1/20 of a wavelength to 1/50 of a wavelength, as well as avoiding the manual data entry into the VAX. With these plans in mind, Cryogenic Mirror Analysis Technology at Ames Research Center will become an even more powerful tool.

#### APPENDIX A: DIAGRAMS

#### APPENDIX B: COMPUTER PRINTOUT

#### APPENDIX C: PHOTOS

#### APPENDIX D: PLOTS

#### APPENDIX E: PROCESS FLOWCHART

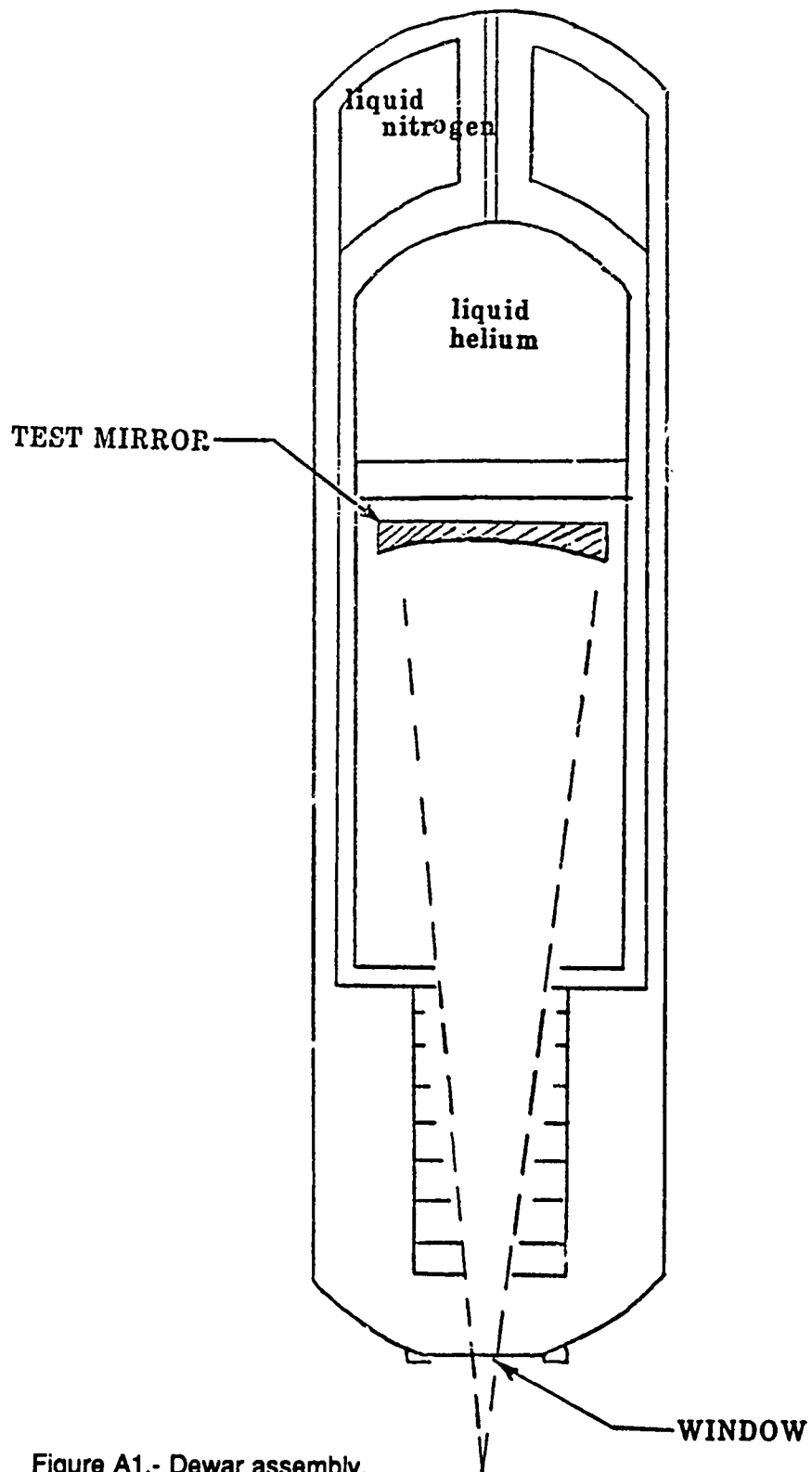


Figure A1.- Dewar assembly.

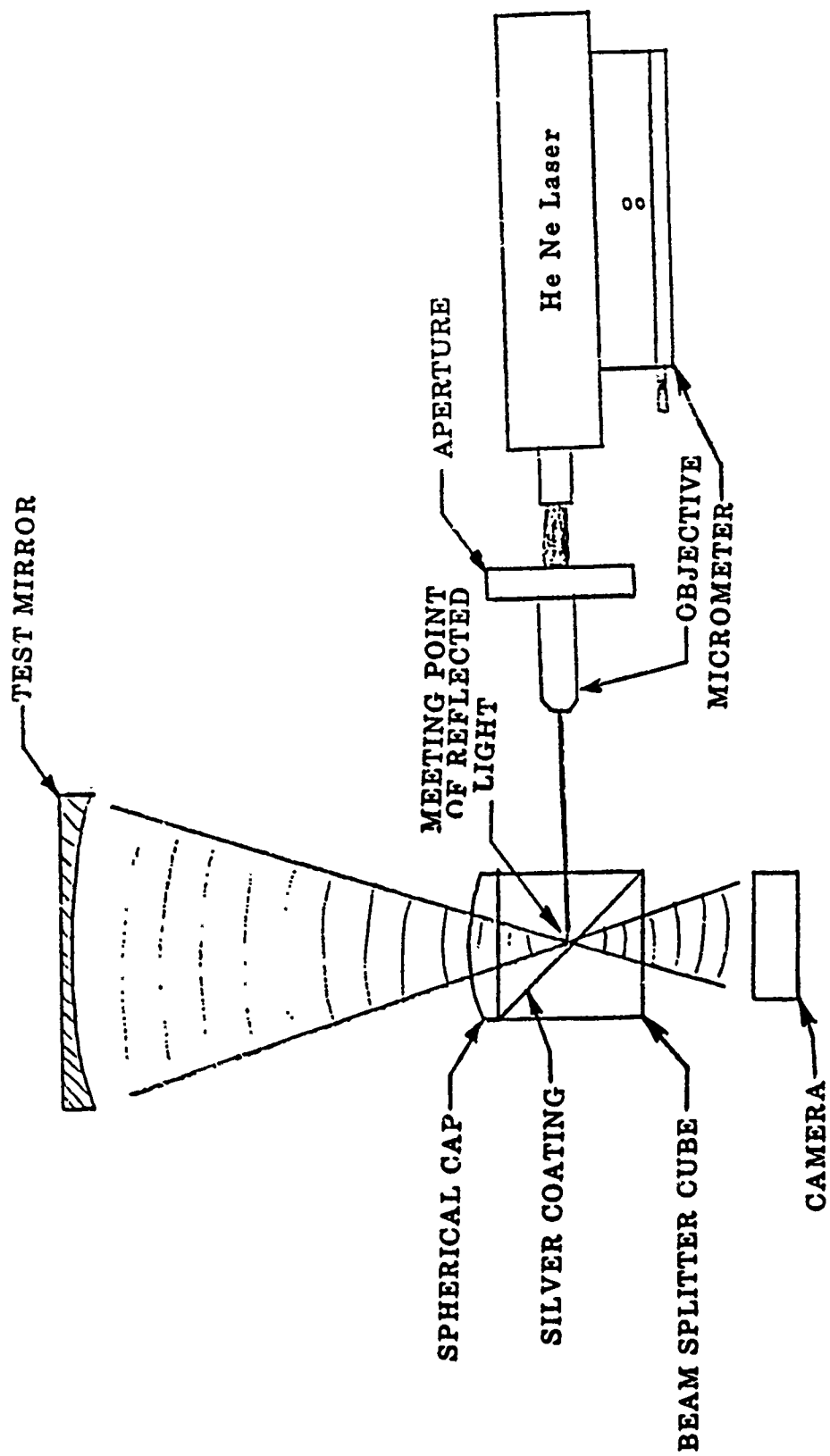


Figure A2.- Interferometer setup.

FRINGE \*\*\*\*\* TECHNICAL PAPER-- SANDOR NAGY

17-JUL-86 12:46:52

--FIDS 403 740 701 466 426 169 129 443

--LIST VERIFY

--TILT FOCUS

--WEDGE -.5

--COBS .25

--STEP .1

--WIDTH .8

--PART

--FSCAN

--END

# APERTURE MASKING

TYPE	CAX	CAY	COX	COY
ELIP	1.0000	1.0000	0.2500	0.2500
--1	538 192	506 181	470 177	433 172
--	END			
--2	562 209	523 205	480 204	435 206
--	248 232	214 248	END	
--3	628 265	605 247	572 238	545 240
--	353 244	360 245	318 250	279 256
--	END			
--4	650 294	613 282	528 274	488 276
--	153 335	END		
--5	674 340	658 323	633 321	604 319
--	381 319	341 323	304 327	265 333
--	131 400	END		
--6	681 383	647 373	548 357	503 352
--	267 371	236 378	197 395	171 403
--7	692 436	656 420	611 413	578 406
--	388 405	339 408	295 412	255 421
--	134 500	END		
--8	695 476	614 459	574 448	540 442
--	365 455	344 354	297 456	270 465
--	146 533	141 552	END	
--9	684 536	648 520	597 499	499 487
--	308 500	283 512	251 527	226 535
--	END			
--10	668 576	579 557	508 533	467 537
--	278 564	243 580	214 589	191 592
--11	635 629	600 618	551 605	507 598
--	269 616	240 627	224 642	215 653
--12	577 686	568 668	510 651	472 646
--	281 666	269 677	267 686	265 697
--13	495 727	466 712	412 700	387 704
END OF DATA				

## PUPIL CENTER AND RADIUS

XC	YC	RAD
414.7500	454.5000	286.4809

Figure B1.- Computer printout 1.

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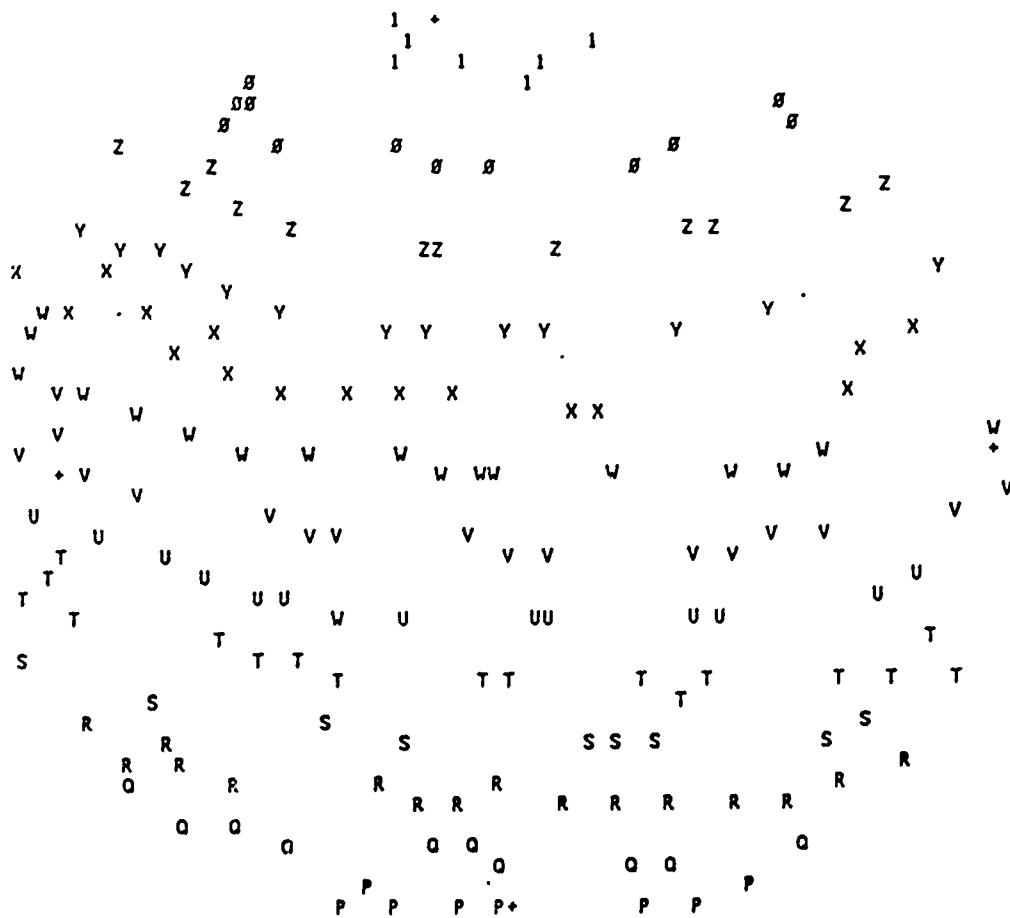


Figure B2.- Computer printout 2.

FRINGE \*\*\*\*\* TECHNICAL PAPER-- SANDOR NAGY

17-JUL-86 12:46:57

WAVEFRON DEVIATION IN UNITS OF WAVES  
TILT AND DEFOCUS MEASURED FROM DIFFRACTION FOCUS  
WAVELENGTH 0.633 MICRONS

	N	RMS
PAW	0	1.676
PLANE	2	0.247
SPHERE	3	0.115
4H ORDER	8	0.107
6H ORDER	15	0.098
8H ORDER	24	0.088
COMPLETE	36	0.086

STREHL RATIO 0.592 AT DIFFRACTION FOCUS

FOURTH ORDER ABERRATIONS

MAGNITUDE	ANGLE	DESIGNATION
WAVES	DEG	
3.136	-94.8	TILT
0.687		DEFOCUS
0.083	0.3	ASTIGMATISM
0.138	-161.2	COMA
0.354		SPHERICAL ABERRATION

FOLLOWING TERMS WERE SUBTRACTED FROM DATA-

TILT FOCUS

RESIDUAL WAVEFRON VARIATIONS EVALUATED AT DATA POINTS

PTS	RMS	MAX	MIN	SPAN	STREHL
169	0.118	0.368	-1.094	1.463	0.575

RESIDUAL WAVEFRON VARIATIONS OVER UNIFORM GRID

PTS	RMS	MAX	MIN	SPAN	STREHL
652.	0.061	0.258	-0.144	0.402	0.863

FRINGE \*\*\*\*\* TECHNICAL PAPER-- SANDOR NAGY

RMS CALCULATED FROM ZERNIKE COEFFICIENTS=0.064

Figure B3.- Computer printout 3.

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FRINGE \*\*\*\*\* TECHNICAL PAPER-- SANDOR HAGY

17-JUL-35 12:47:03

CONTOUR	STEP	WIDTH	PAGE	SIZE	-M-	-H-	-P-	-O-
	0.100	0.800	2.000		0.150	0.050	0.050	0.150
+	+	++	+	11+		+		

[illegible]

### ZERNIKE POLYNOMIAL COEFFICIENTS

0.0000	0.0000	0.0000	0.0541	0.0277	-0.0290	-0.0120	0.0349
-0.0267	0.1010	-0.0141	0.0221	-0.0015	0.0352	-0.1096	0.0219
-0.0208	0.0117	-0.0473	-0.0066	-0.0629	-0.0176	0.0400	0.0766
0.0044	0.0207	-0.0214	0.0012	-0.0492	-0.0035	-0.0155	0.0119
-0.0102	-0.0213	-0.0104	0.0020				

RESIDUAL WAVEFRON VARIATIONS OVER UNIFORM MESH

PTS	RMS	MAX	MIN	SPAN	VOLUM
652.	8.861	8.258	-8.144	8.482	8.413
END OF DATA					

**Figure B4.- Computer printout 4.**

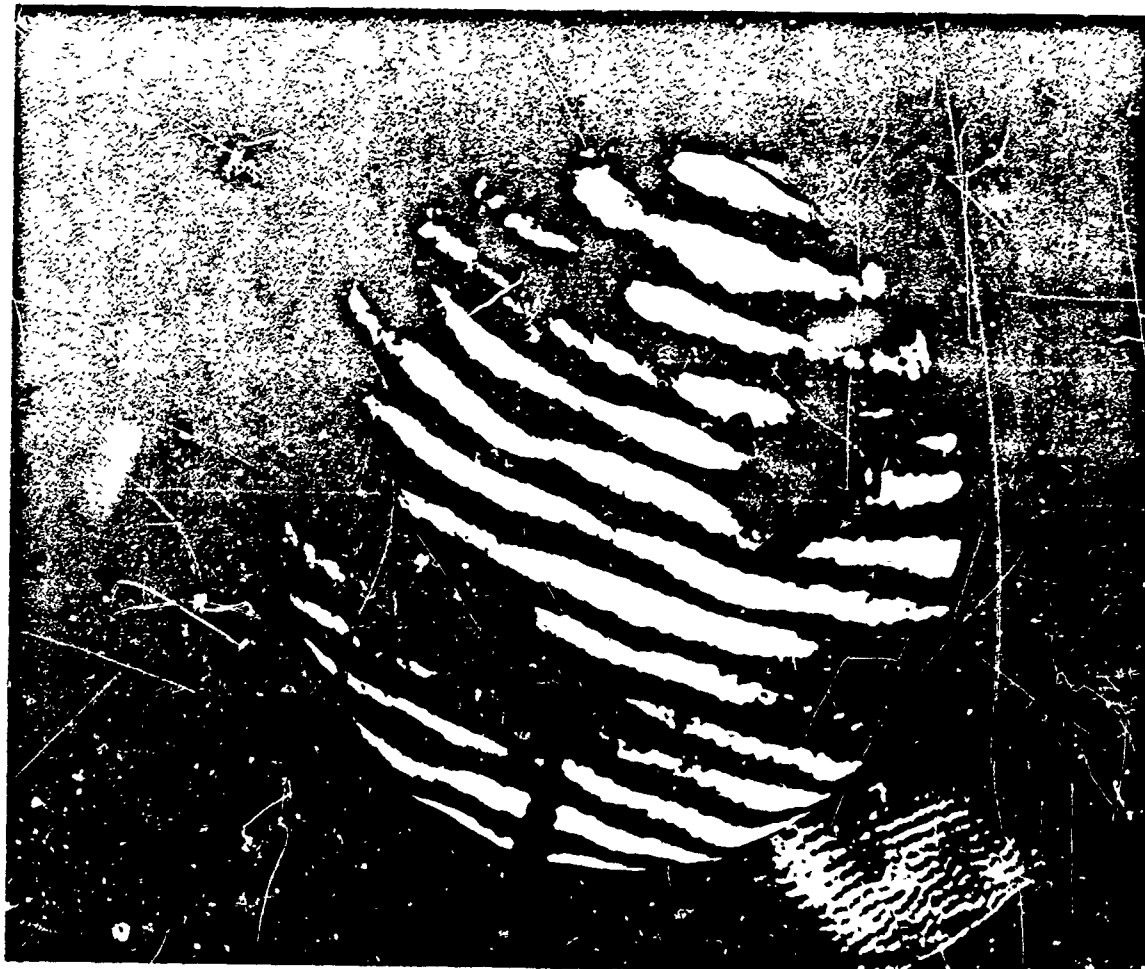


Figure C1.- Interference fringe pattern.

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ORIGINAL PAGE  
BLACK AND WHITE PHOTOGRAPH

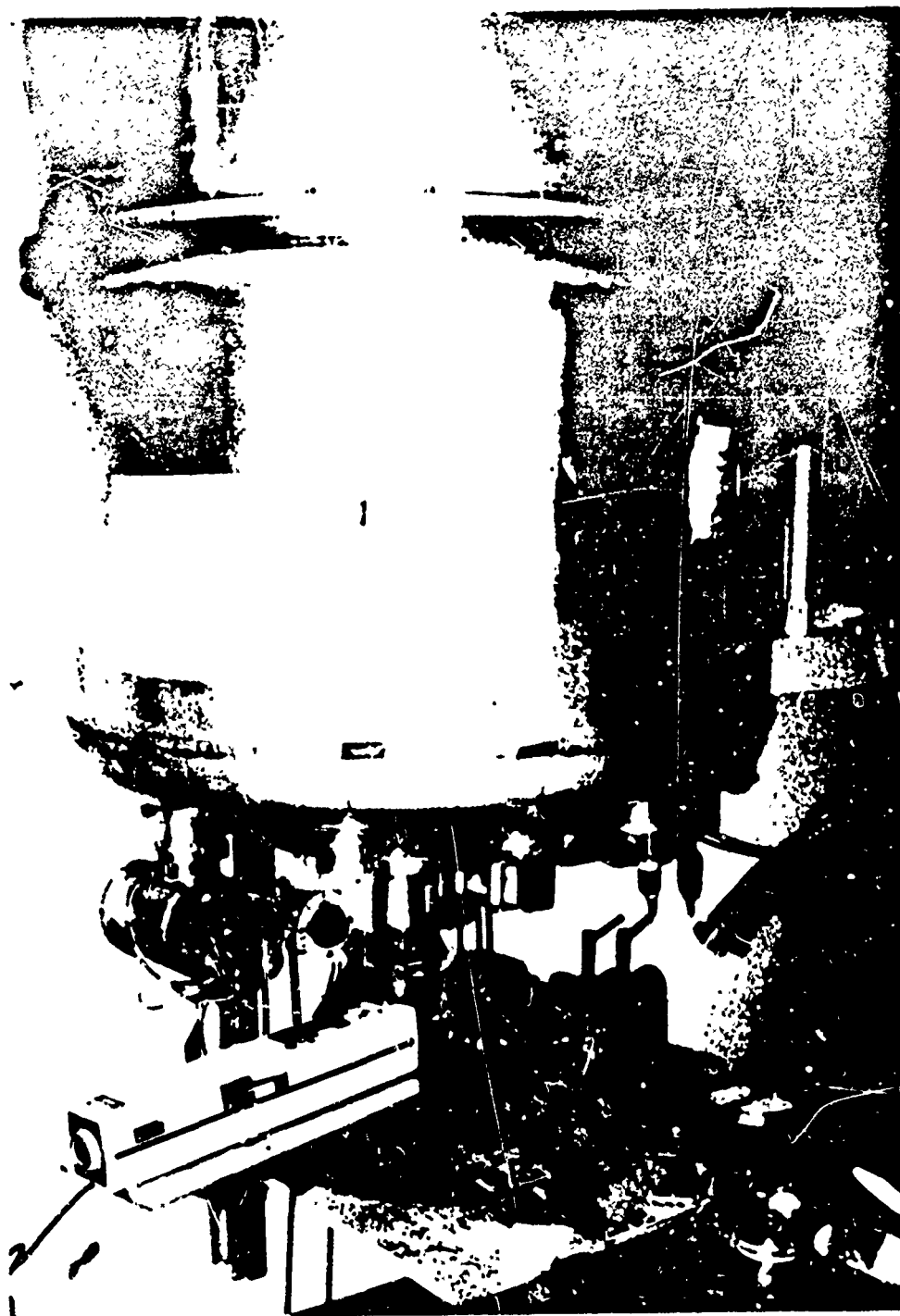


Figure C2.- Laser Interferometer with bottom of dewar.



Figure C3.- Dewar assembly.

ORIGINAL PAGE  
BLACK AND WHITE PHOTOGRAPH



Figure C4.- Pyrex Hexcore Mirror 1A mounted to bottom of dewar assembly.

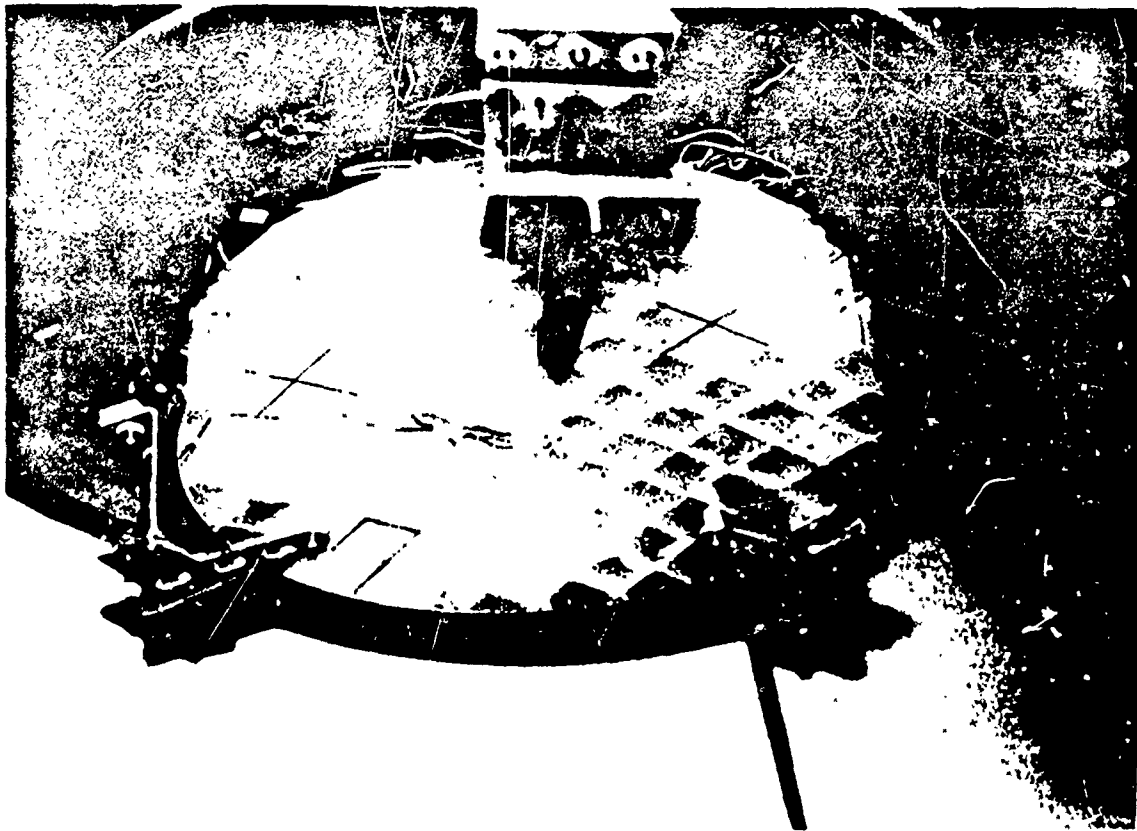


Figure C5.- Fused silica ultralightweig.      -ed mirror.

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FRINGE

WAX

REF

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-.0208	.0117	-.0473	-.0066	-.0629	-.0176	.0040	.0766
.0044	.0207	-.0214	.0012	-.0492	-.0035	-.0155	.0119
-.0182	-.0213	-.0104	.0028				

POLYNOMI

FIDS 100 200 200 100 100 0 0 100

WEDGE 0.5

STEP .1

WIDTH .4

COBS .25

PART

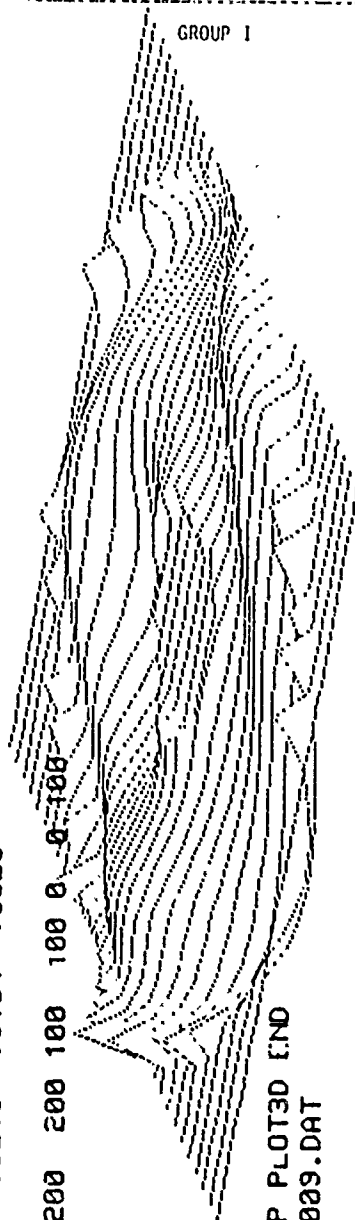
END

DANA WAMAP PLOT3D END

\$ TYP FOR009.DAT

All Zernike Coefficient Contributions

GROUP 1



WAVEFRONT VALUES

RADIUS

17-JUL-88  
17:23:04

1A

Figure D1.- Plot 1A.

\$ TYP FOR025.DAT

FRINGE

UAX

REF

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-.0208	.0117	-.0473	-.0066	-.0629	-.0176	.0040	.0766
.0044	.0207	-.0214	.0012	-.0492	-.0035	-.0155	.0119
-.0182	-.0213	-.0104	.0028				

POLYNOMI

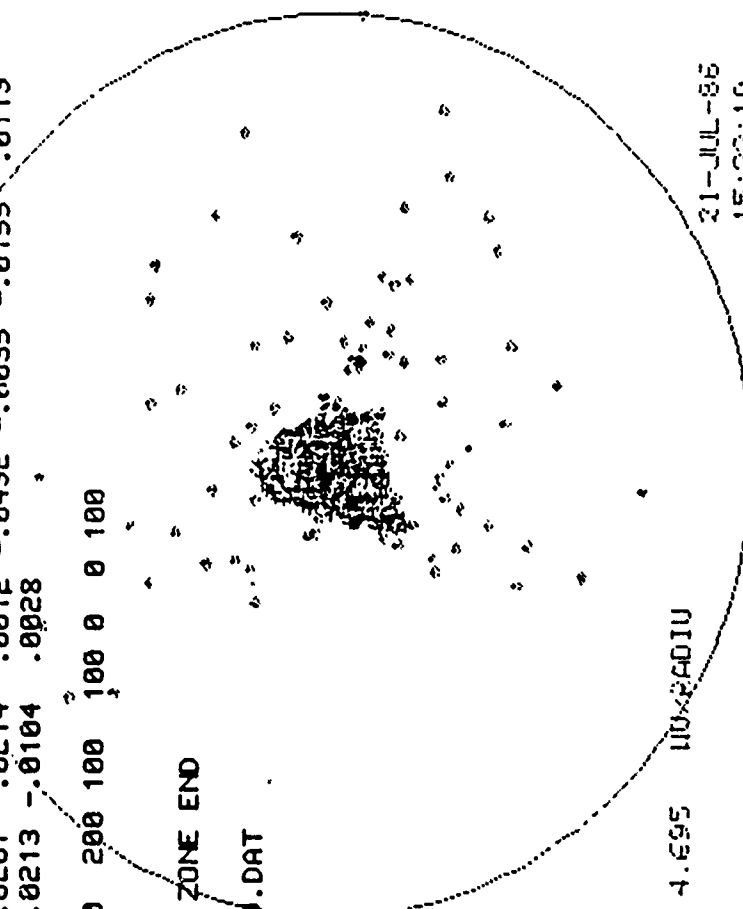
FIDS 100 200 200 100 100 0 0 100

PART

END

ESCAN GSPOT ZONE END

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RADIUS = 4.695 100xRADIU

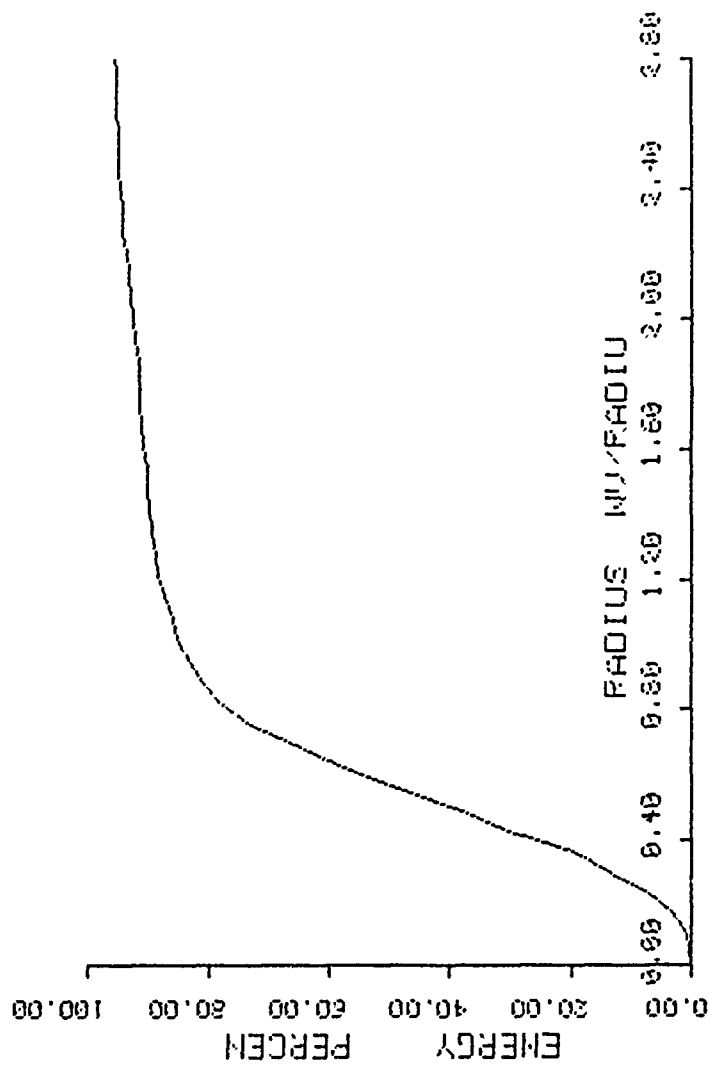
FRINGE

21-JUL-86  
15:22:10

Figure D2.- Plot IB.

\$ typ for009.dat

GEOMETRIC SPOT



IC

17-JUL-66  
17:42:13

Figure D3.- Plot IC.

### Radial Contribution (spherical aberration)

11 A

GROUP II

```

*
$ TYP FOR025.DAT

FRINGE
UAX
REF

.0000 .0000 .0000 .0000 .0000 .0349
.0000 .0000 .0000 .0000 -.0096 .0000
.0000 .0000 .0000 .0000 .0000 .0766
.0000 .0000 .0000 .0000 .0000 .0000
.0000 .0000 -.0104 .0028

POLYNOMI
FIDS 410 528 612 330 412 131 213 332
WEDGE 0.5
STEP .1
WIDTH .4
CIRS .25
PART
END

DANA WAMAP PLOT3D END
$ TYP FOR009.DAT

```

301053 3010533181

一、二、三、四、五、六、七、八、九、十、十一、十二、十三、十四、十五、十六、十七、十八、十九、二十、二十一、二十二、二十三、二十四、二十五、二十六、二十七、二十八、二十九、三十、三十一、三十二、三十三、三十四、三十五、三十六、三十七、三十八、三十九、四十、四十一、四十二、四十三、四十四、四十五、四十六、四十七、四十八、四十九、五十、五十一、五十二、五十三、五十四、五十五、五十六、五十七、五十八、五十九、六十、六十一、六十二、六十三、六十四、六十五、六十六、六十七、六十八、六十九、七十、七十一、七十二、七十三、七十四、七十五、七十六、七十七、七十八、七十九、八十、八十一、八十二、八十三、八十四、八十五、八十六、八十七、八十八、八十九、九十、九十一、九十二、九十三、九十四、九十五、九十六、九十七、九十八、九十九、一百。

**Figure D4.- Plot IIA.**

11 13



**Figure D6.- Plot IIC.**

111 A

14:04:41  
23-III-71

**Figure D7.- Plot IIIA.**

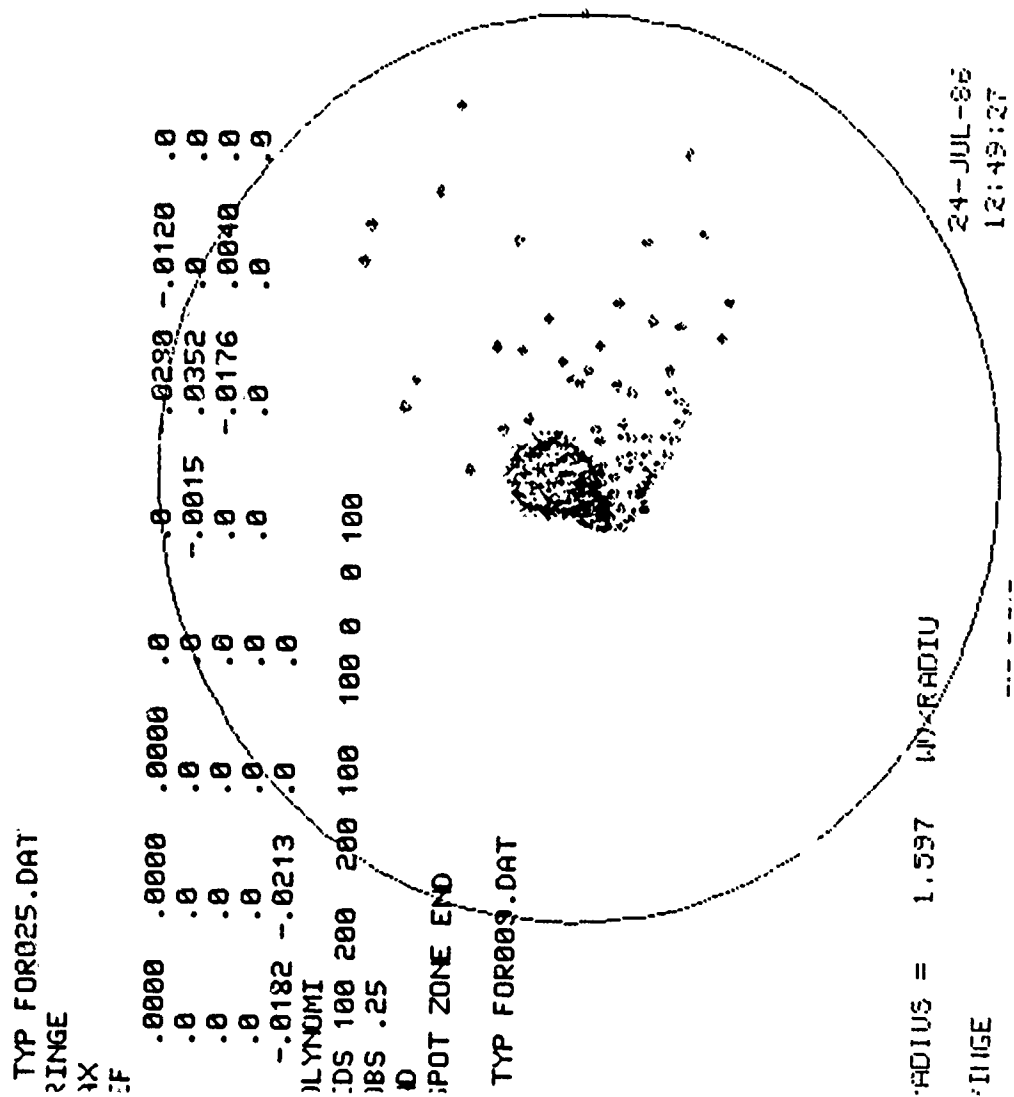
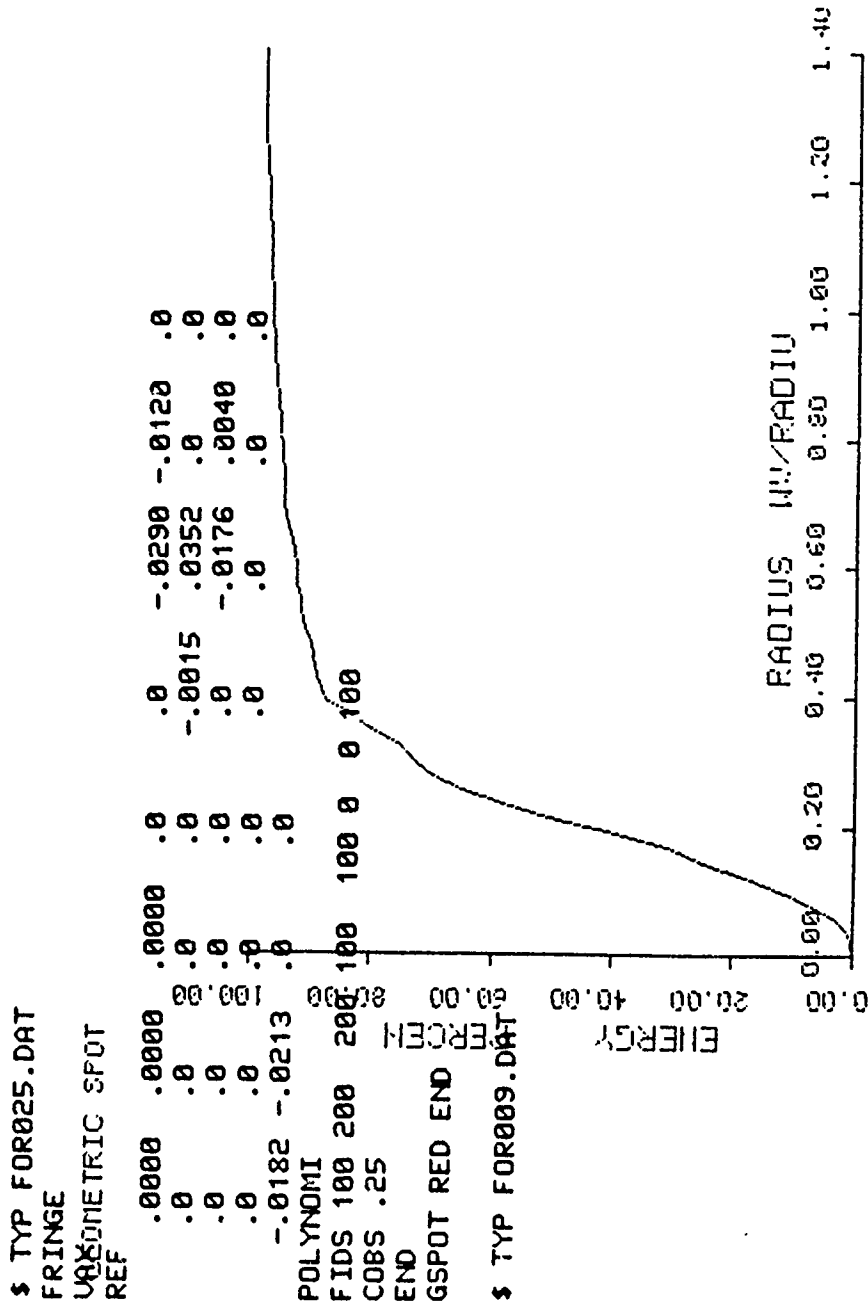


Figure D8.- Plot IIIB.

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III C

23-JUL-86  
14:27:18

FRINGE

Figure D9.- Plot IIC.

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FRINGE  
VAX  
REF

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.0000	.0000	.0000	-.0066	-.0629	.0000	.0000	.0000
.0000	.0000	.0000	.0000	.0000	.0000	-.0155	.0119
.0000	.0000	.0000	.0000				

POLYNOMI

FIDS 410 528 612 330 412 131 243 332

WEDGE 0.5

STEP .1

WIDTH .4

CUBS .25

PART

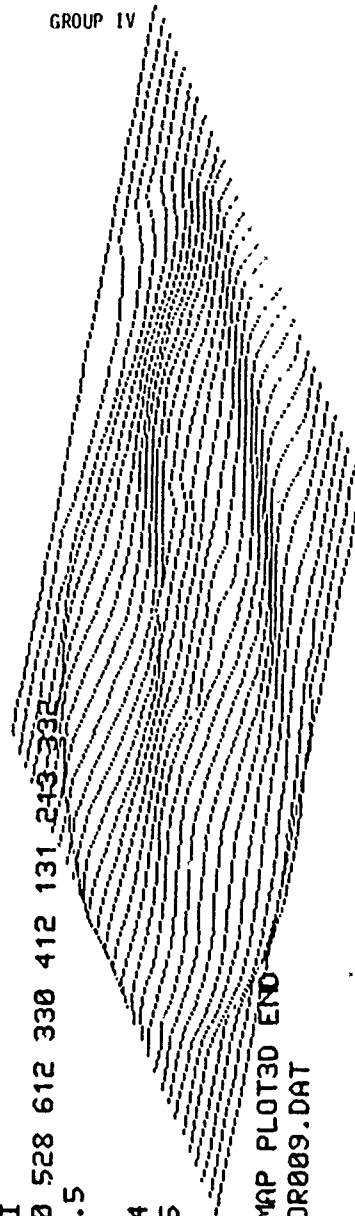
END

DANA WAMAP PLOT30 END

\$ TYP FOR009.DAT

20 Contribution (astigmatism)

GROUP IV



WAVELENGTHS RADIUS

IV A

17-JUL-86

Figure D10.- Plot IVA.

BTB

45:4:0:31  
45-777-4:0

95

\$ TYP FOR025.DAT

FRINGE

MAXIMETRIC SPOT

REF

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.0	.0	.0	-.0066	-.0629	.0	.0	.0
.0	.0	.0	.0	.0	.0	-.0155	.0119
.0	.0	.0	.0	.0	.0	.0	.0

POLYNOMI

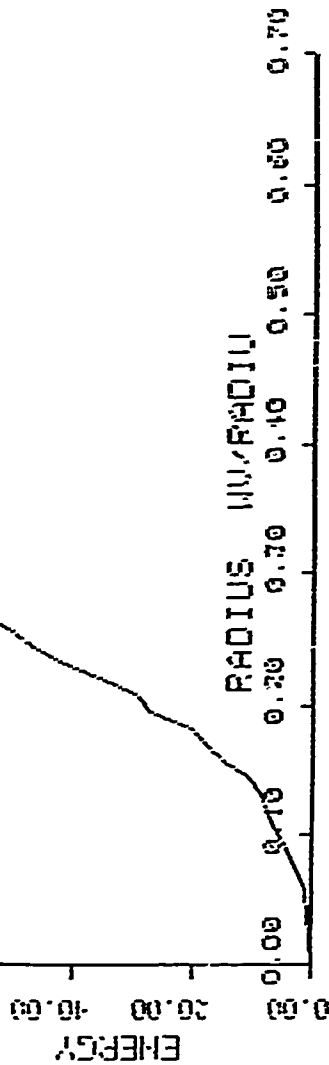
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COBS .25

END

GSPOT RED END

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27-11-82

Figure D12- Plot IVC.

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-.0267	.1010	.0000	.0000	.0000	.0000	.0000	.0000
.0000	.0117	-.0473	.0000	.0000	.0000	.0000	.0000
.0000	.0000	.0000	-.0492	-.0035	.0000	.0000	.0000
.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

POLYNOMI

FIDS 410 5E: 612 330 412 131 215-352

WEDGE 0.5

STEP .1

WIDTH .4

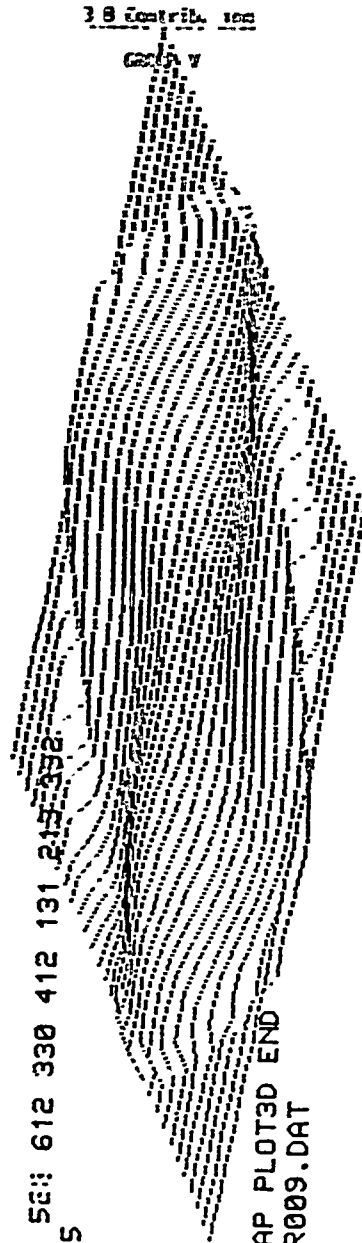
COBS .25

PART

END

DANA WAMAP PLOT3D END

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7A

17-JUL-86  
11:15:34

WAVEFRONTS RADIUS

Figure D13.- Plot VA.

\$ TYP FOR025.DAT

FRINGE

MAX

REF

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.0	-.0141	.0221	.0	.0	.0	.0	.0
.0	.0	-.0066	-.0629	.0	.0	.0	.0
.0	.0	.0	.0	.0	-.0155	.0119	.0
.0	.0	.0	.0	.0	.0	.0	.0

POLYNOMI

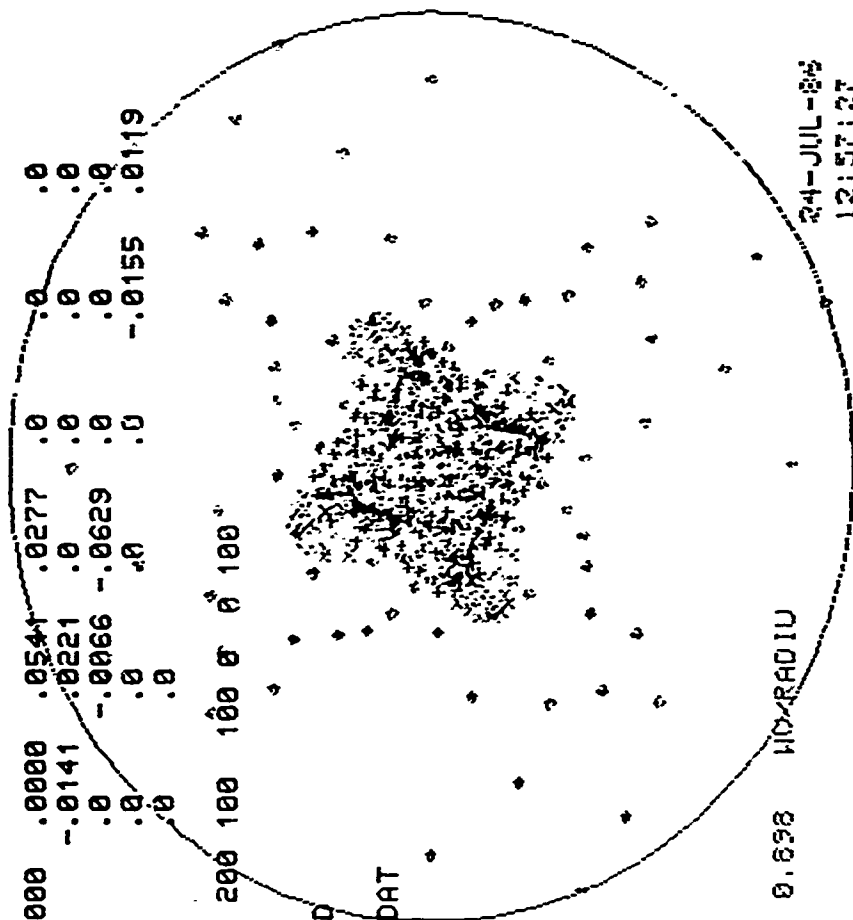
FIDS 100 200 100 100 0 100

COBS .25

END

GSPOT ZONE END

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12:57:27

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Figure D14.- Plot VB.

59

TYP FOR025.DAT

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VAX  
REF

.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
-.0208	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0219
.0000	.0000	-.0214	.0012	.0000	.0000	.0000	.0000	.0000	.0000
.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

POLYNOMI

FIDS 410 528 612 330 412 131 213 530

WEDGE 0.5

STEP .1

WIDTH .4

COBS .25

PART

END

DANA WAMAP PLOT30-ENG

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4.0 Contribution

GROUP

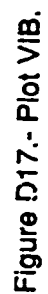
WAVEFRONT WAVES RADIUS

VI A

17-JUL-85  
14157131

Figure D16.- Plot VIA.

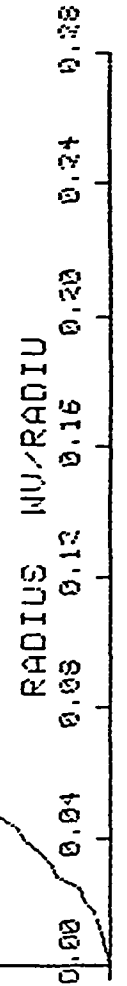
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END  
GSPOT RED END  
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ENERGY



# ENGINE

VI C

**Figure D18.- Plot VIC.**

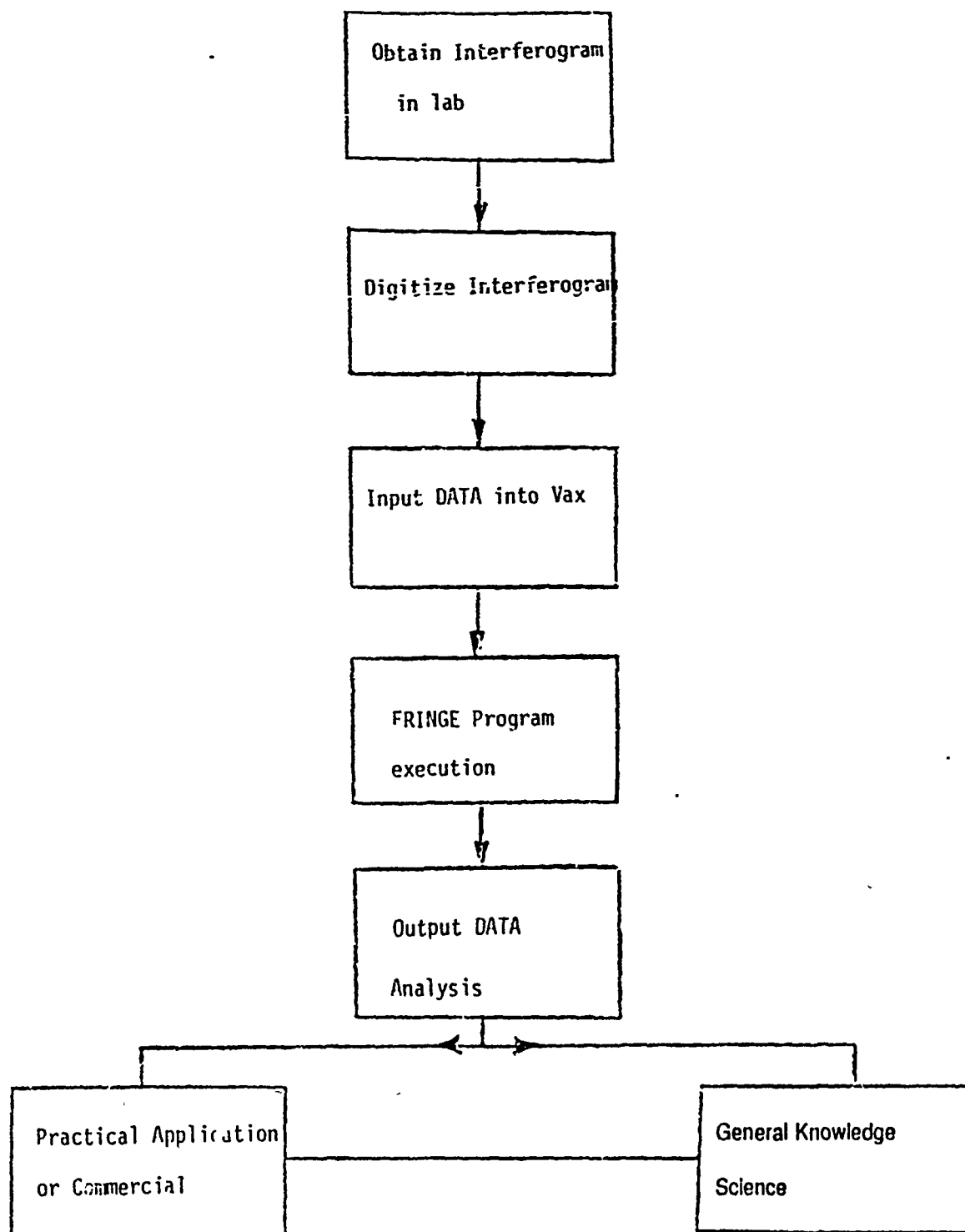


Figure E1.- Fringe analysis process flowchart.

N89-18391

513-54  
175-42  
78

## PILOT PERFORMANCE

Jennifer Nicholls

Today, flight plays a very important role in the world. It is used for transportation of people and goods, and aids in the exploration of space as well as playing a major role in the defense of the country. Therefore, every year enormous amounts of time and effort are put into research and production which is aimed at improving planes and other aircraft. Producing aircraft that will fly faster, farther, and on less fuel is a major goal of aerospace researchers all over the world. However, the vehicle itself is not the only important factor in the flight process. Nothing would be possible without the pilots.

For many years, the emphasis has been placed on the aircraft, rather than on those who fly the aircraft. This is largely due to the relative safety of flying. For years everyone has heard that it is much safer to fly in an airplane than it is to drive an automobile, and in comparison the number of aircraft accidents is considerably less than the number of automobile accidents. On the other hand, when a plane crashes, the number of people involved is much greater than the number in a car accident, and the results are much more disastrous. Just in the last few years there have been several major accidents that have shown that flying is not quite as safe as it was thought to be. Sixty-five percent of these accidents are a result of pilot performance decrements, and so it is obvious that there is a need to reduce that figure. Five years ago Congress mandated that a study be done to evaluate pilot performance. This includes workload, circadian rhythms, jet lag, and any other factors which might affect a pilot's performance in the cockpit.

The purpose of this study is to find out when and why the decrements in a pilot's performance occur and how to remedy the situation. Within a flight crew each member brings his/her own characteristics into the cockpit with him/her. The influence of these characteristics combine with conditions of the flight and crew coordination to determine the efficiency of the entire crew, and therefore the safety of the flight.

The majority of air accidents attributed to human factors, result from inadequate knowledge, communication errors, poor pilot judgment, and failure to use available resources, all of which are decrements of pilot performance. However, the major factor contributing to these decrements is pilot fatigue. There are many basic conditions that contribute to pilots' fatigue. 1) Loss of sleep or alterations in sleep patterns. 2) Circadian rhythm desynchronization. 3) Long duty hours. 4) Other human factors: low activity periods, boredom, poor nutrition, and alcohol or drug use to overcome sleeping problems. All of these factors lower the capacity of the pilot, and when the demand on him/her exceeds his/her capacity, the probability of error is greatly increased.

The first and most obvious cause of pilot fatigue is deviations in normal sleep patterns. Night flying or flying through several different time-zones induces situations in which normal sleep patterns cannot be observed. On many overseas flights pilots are required to be alert and at a high work output level at a time when they are normally asleep. Moreover, they may arrive somewhere during daylight hours during

which they may have a hard time sleeping. They then may have only a few days to adjust before they must fly the return flight, never allowing their body clocks to adjust, and therefore never sleeping as long or as well as they should. This condition of lack of sleep tends to produce a narrowing of attention and a tendency to commit errors due to short-term memory losses which result from a diversion of attention.

The desynchronization of body clocks is another major cause of pilot fatigue. Many circadian rhythms are present in the human body. These rhythms all represent various physiological and behavioral functions. Normally these rhythms are synchronized, although they are out of phase with one another. These rhythms are controlled by at least one circadian "clock." These clocks are in turn synchronized to the environment, and cannot immediately be reset as the outside environment changes time. Thus, a time-zone traveler finds his/her internal clocks no longer in synchrony with the external ones. And as a result, his/her normal actions such as sleeping are no longer allowed to happen when they should, and when the traveler does sleep, his/her sleep will not be as long or as restful. Slowly these clocks will begin to adjust, but different rhythms adjust at different rates, which results in internal desynchronization within the traveler. Internal and external desynchronization combine to cause fatigue, and in turn, fatigue and sleep loss combine to cause a variety of symptoms: irritability, boredom, headache, and lightheadedness. All of which tend to cause decrements in a pilot's performance, causing disturbances in vigilance and short-term memory.

There are several other causes of pilot fatigue. These include boredom, long duty hours, poor nutrition etc. Earlier studies of pilots have shown that fatigue caused by repeated flights in one day tended to bring on boredom and a lack of concern for precise accuracy on the instruments.

All of these small problems within an individual are greatly intensified when they are present in every member of a crew. The flight crew is susceptible to the effects of group dynamics. Therefore, an emotional upset of one person within the crew greatly affects the function of the entire group. So, it is now becoming obvious that these problems must be fully understood before a solution can be found, and flight can become safer than it already is.

In order to address these issues, find the extent to which this problem exists, and find some solutions to the problem, a comprehensive research program was set up. The program is divided into two parts, a series of field studies and a series of simulated missions. The field studies have as their objectives: (a) to determine the psychological and physiological responses of individual crew members to various flight schedules, with an emphasis placed on documenting circadian physiology, sleep quality and quantity, and fatigue and mood states; (b) to identify relevant individual attributes which may determine, or help predict, the responses of pilots to fatigue and circadian factors; (c) to identify any personal adaptive strategies already being used by the flight crew members; and (d) to identify significant operational factors which affect individual responses to fatigue and circadian factors (as defined by Graeber, Foushee and Lauber in *Dimensions of Flight Crew Performance Decrements: Methodological Implications for Field Research*).

In order to achieve all of these objectives, pilots from all types of flights were needed. Airlines were contacted and schedules were scanned to make sure that all considerations were tested (i.e., early morning, late night, or multiple time-zone crossings). Pilots who fit these schedules were then asked to volunteer as subjects. They were asked to wear a "Vitalog" physiological recorder for a whole flight sequence of between three and twelve days, depending on the nature of the exact study being done (long haul or short haul). The "Vitalog" measures rectal temperature, heart rate, and nondominant wrist activity. Each measurement is made every two minutes. During the flight a NASA observer rides in the jumpseat of the cockpit to record extra data (i.e., weather equipment troubles, etc.). This observer also helps to enforce subject cooperation and to provide information on crew coordination success.

The subjects are also asked to wear the "Vitalog" before their trip to determine "normal" data, and for up to a week after the trip to observe recovery and return to normalcy. Volunteers are also asked to keep a daily log (fig. 1) which asks for things like wake up time, meals and exercise, and they also fill out a mood chart (fig. 2) every two hours of their waking day. Before the study a background questionnaire helps to tell which pilot attributes this pilot brings into the cockpit with him/her.

The second part of the study is the study of crew performance in an aircraft simulator. This provides a controlled environment in which any chosen circumstance can be induced. The objectives of the simulator studies are: (a) to determine any behavioral and crew performance changes which may be associated with certain types of duty cycles; (b) to determine the operational significance of these changes with regard to flight safety and operational efficiency; (c) to identify possible adaptive strategies that well-coordinated crews may use on the flight deck to cope with the impact of various flight schedules; and (d) to determine whether certain individual attributes are limited to crew coordination and good performance (as defined by Graeber, Foushee and Lzuber in *Dimensions of Flight Crew Performance Decrements: Methodological Implications for Field Research*).

Fully qualified flight crews are asked to fly full length simulated missions. These simulations include operational problems in an attempt to test crew interaction and coordination. Each crew is evaluated by a team of trained observers. The observers use computerized data from the simulator of the handling of the aircraft, and video tapes of the crew inside the simulator. These simulations are run on two types of crews. Half of the crews have just come off a long layoff period, and the other half of the crews have just finished one of the flights on the field study schedule. The evaluators are not told the condition of the crew being evaluated and therefore provide totally objective observations. This simulator study used two groups of ten B-737 crews.

There will also be a comprehensive sleep study done during this time. The daily log data from the field study provides some data on sleep though it is mostly subjective. A study among long-haul B-747 crews has been established. This study will have four crews of three members each of four different international carriers. Each subject will be required to spend the first night of the layover in a sleep laboratory. Before the trip the subject will have spent time in the same type of laboratory so that baseline data may be established for comparison with the layover sleep data.

There will also be a posttrip requirement to be compared to the other two sleep situations. Sleep in the laboratories will be much like it would be in a hotel or home or wherever the pilot would otherwise be sleeping.

All of these studies together provide a most extensive crew performance research project. At the conclusion of these studies it is hoped that a much more detailed description of the problem is known. The short-haul section of the study has been completed, though data on the long-haul portion is still being collected. The short-haul study actually used 91 crew members and 47 trips to total 821 flights and 924 flight hours. The study was done in the Eastern United States using DC-9s, B-737s, and B-727s. The results of neither study have been published.

Preliminary interpretation of data and previous studies have found some general facts about fatigue and sleep for pilots. Pilots' sleep patterns tend to be more greatly disturbed on eastbound flights than on westbound flights; though either direction caused activity and heart rate during sleep to increase. The change of time zones always imposes an offset of normal sleeping hours on the traveler and the quality and quantity of sleep are always disturbed. As a result the temperature readings show an actual shift in the phase of the rhythms which govern the body's functions. It has also been observed that the sleep/wake cycle tends to reset faster than the core temperature rhythms.

In general, younger "evening" type pilots adjusted to time shifts better than anyone else, and everyone adjusted better flying in a westward direction than in an eastward one. Even though these results are far from complete and have not yet been analyzed, they are already helping to develop a new understanding of the problem of pilot fatigue, and along with this new understanding come better ideas for a solution. When solutions can be developed and introduced into what is already one of the safest forms of transportation, the results should benefit everyone in the aviation field as well as everyone else who gets on an airplane even once.

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DAILY LOG			
			GMT
WAKE UP (LOCAL)			
SLEEP DURATION (hrs)			Rate Sleep
AWAKENINGS (GMT)			
GET UP			
EXERCISE:			
SHOWER/BATH			
DEPART HOME/LAYOVER			
ON DUTY (LOCAL):			
OFF DUTY (LOCAL):			
ARRIVE HOME/LAYOVER			
NAPS FROM: TO:			
FROM: TO:			
IN BED			
ASLEEP			
SEGMENTS FLOWN:			
COMMENTS:			

Rate from least (1) to most (5):  
 DIFFICULTY ARISING? 1 2 3 4 5  
 HOW RESTED YOU FEEL? 1 2 3 4 5  
 DIFFICULTY FALLING ASLEEP? 1 2 3 4 5  
 HOW DEEP WAS YOUR SLEEP? 1 2 3 4 5

DAILY LOG		
MEAL	TIME	PLACE
B L D S		
B L D S		
B L D S		
B L D S		
B L D S		
COFFEE/TEA/COLA:		
BOWEL MOVEMENTS:		
URINATIONS:		
NUMBER CIGARETTES: (A.M.) (P.M.)		
MEDICATION: TIME:		
Did you experience any of the following?		
HEADACHE	BURNING EYES	
RACING HEART	CHILLS	
CONGESTED NOSE	NAUSEA	
WATERY EYES	LIGHT-HEADED	
FLUSHED FACE	FEVERISH	
DIZZINESS	DISORIENTATION	
CONSTIPATION	SWEATING	
BACK PAIN	DIARRHEA	
SORE THROAT	UPSET STOMACH	
FEELING WEAK	SHORT OF BREATH	
Other		

Figure 1.- Daily log.

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Tube \_\_\_\_\_

Tube \_\_\_\_\_

**MOOD CHECKLIST**

GMT _____	not at all	a little	moderately	quite a bit	extremely
Leg/LO _____					
active	0	1	2	3	4
vigilant	0	1	2	3	4
annoyed	0	1	2	3	4
carefree	0	1	2	3	4
cheerful	0	1	2	3	4
considerate	0	1	2	3	4
defiant	0	1	2	3	4
dependable	0	1	2	3	4
sleepy	0	1	2	3	4
dull	0	1	2	3	4
efficient	0	1	2	3	4
friendly	0	1	2	3	4
full of pep	0	1	2	3	4
grouchy	0	1	2	3	4
happy	0	1	2	3	4
jittery	0	1	2	3	4
kind	0	1	2	3	4
lively	0	1	2	3	4
pleasant	0	1	2	3	4
relaxed	0	1	2	3	4
forgetful	0	1	2	3	4
sluggish	0	1	2	3	4
tense	0	1	2	3	4
clear thinking	0	1	2	3	4
tired	0	1	2	3	4
hard working	0	1	2	3	4

**MOOD CHECKLIST**

GMT _____	not at all	a little	moderately	quite a bit	extremely
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happy	0	1	2	3	4
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kind	0	1	2	3	4
lively	0	1	2	3	4
pleasant	0	1	2	3	4
relaxed	0	1	2	3	4
forgetful	0	1	2	3	4
sluggish	0	1	2	3	4
tense	0	1	2	3	4
clear thinking	0	1	2	3	4
tired	0	1	2	3	4
hard working	0	1	2	3	4

MOST DROWSY

MOST DROWSY

MOST ALERT

MOST ALERT

Figure 2.- Mood checklist.

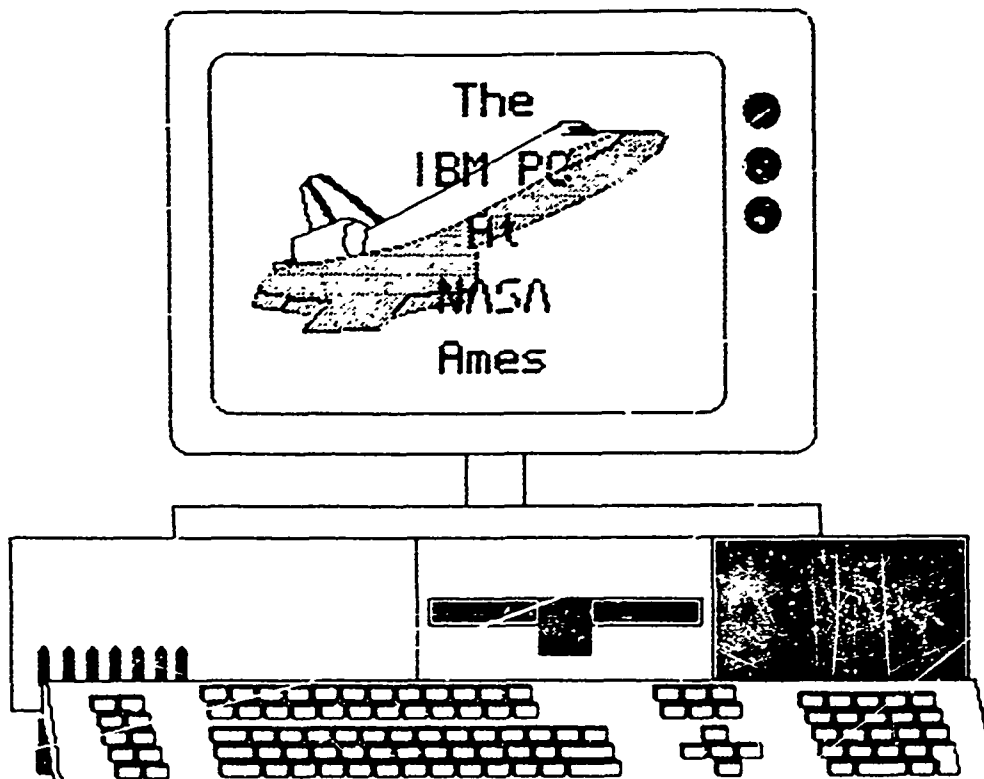
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James P. Peredo

At NASA Ames, the IBM PC has penetrated the computer user's world. Along with the Apple Macintosh, the PC is now the most common personal computer at the Center. With some of the latest in software and hardware technology, the IBM PC has been made into a most helpful tool--with an eye on the market and a hand in the future of Ames.

Like any other large company, Ames relies very much on its computing power to get work done. And, like any other large company, finding the IBM PC a reliable tool, Ames uses it for many of the same types of functions as other companies. Presentation and clarification needs demand much of graphics packages. Programming and text editing needs require simpler, more-powerful packages. The storage space needed by NASA's scientists and users for the monumental amounts of data that Ames needs to keep demand the best database packages that are large and easy to use. Availability to the Micom Switching Network combines the powers of the IBM PC with the capabilities of other computers and mainframes and allows users to commu-

nicate electronically. These four primary capabilities of the PC are vital to the needs of NASA's users and help to continue and support the vast amounts of work done by the NASA employees.

In the early days of the computer, there were no computer graphics--mostly because these computers were large mainframes that were dedicated mainly to solving problems. Though there are graphics packages on mainframes today, they fail to be as user friendly as the PC. It was with the advent of the personal computer that graphics packages became practical and advantageous. At Ames the two main uses for graphics are for clarification needs and presentation needs.

Freehand graphics are a type of computer graphics where absolute precision is not necessary. In the Ames user's world, a freehand graphics package would be perfect for diagrams and flowcharts, etc. After the arrival of the Apple Macintosh and its trendsetting MacPaint freehand graphics program, a call went out for similar graphics programs for other machines. Seeing a large market of IBM PC users, software manufacturers put out competitive products resulting in a few excellent packages. The purchase of these packages for Ames's users improves the worker's quality of work and saves him/her much time. Where clarification needs are expressed, freehand graphics on the IBM PC deliver.

But the more technical, presentation-quality graphics are also needed. Presentations are important to the Center and, along with adequate printing capabilities, can greatly influence trends at Ames. The kinds of packages available for the PC make for very professional documents. Dona Z. Meilach, in *PC Week* magazine, states that using computer graphics for presentation requires that these documents "be accurate, easy to interpret, and have impact." The major failures of presentation graphics are too much clutter and a lack of imagination. Moreover, with today's latest in software, Ames's PC users can make top-quality presentations with a touch of flair added in for good measure.

Computer users of today have better control of their jobs with today's graphics than the computer user of yesteryear. Whether graphics are needed for official, important presentations or just good clarity to help in understanding a problem, today's IBM PC has the capabilities to provide for almost all graphics needs. Ames users are aware of this and utilize it to their best advantage.

Word processing capabilities have also advanced considerably. Again, like graphics, word processing became popular as a computer-related function only after the arrival of the personal computer. Though word processing is used mainly for text articles (e.g., reports, etc.), nondocument mode is available for programming.

Here at Ames, word processors are found all over the center. The advantage of doing reports, outlines, and so on, on computers, rather than on typewriters is greatly appreciated. On the PC such programs used at Ames are PC Write, GemWrite, Lotus 1-2-3, and Wordstar 2000. Many of the best packages today are even capable of combining graphics and text. To be sure, almost all of today's typewriting is done on personal computers, and most of the personal computers at Ames are IBM PCs.

Programming with word processors must be done in nondocument mode. Christine Falsetti writes informally: "Normally, when you type a document it adds in special characters and flags, to format the document for printing, and so on--this is document mode." For this reason, a nondocument mode was created for programming. That way, programs don't "choke because [the computer] wouldn't know what to do with that stuff." The subject of programming, especially here at Ames, is too immense to approach in this type of paper, but suffice it to say that programming is used for almost everything--from simple menu programs that make human interface more friendly, to the most complex programs that only few understand.

The IBM PC plays a significant part in Ames' continuing work, especially with the latest in word processing software. Users make good use of this software and use it for all of their text editing needs--either programming or documenting. With the great amount of competition on the market, Ames' PC users can pick from the cream of the crop--and do just that.

**"Database-management system:** The collection of software required for using a database that handles the storage allocation, retrieval and update of records by presenting multiple views of the data to the users and programmers." So says the "Database Software Chart Definitions" in a recent *PC Week*. Why have a database-management system at NASA Ames? Because there is an ever-increasing amount of data that need to be kept--and in some sort of orderly fashion! Database management is vital to such a huge operation. For example, the number of employees is so large and the keeping of personnel records must be current. Salaries, addresses, phone numbers, etc., all need to be kept on file and managed in an orderly way--that's where good software comes in.

Flat-file database managers are not good software, but by understanding what they are, one can deduce what a good manager is. Flat files are two-dimensional file managers that provide no systematic view of looking at data. They are able to look at one file at any given time and must look at all the data instead of a certain field of data (i.e., names, salaries, phone numbers, etc.). In other words, in a personnel database, a flat-file management system would present all the data in one large group and not organize, say, the names together and a listing of personal information under each name.

On the other hand, hierarchical file database managers *are* good software. As the name suggests, these types of managers present a logical order, placing important items, or "flags," in a group. In a personnel file, the only group of data that exists would be a file of names--each followed by personal information. These types of systems make management easier and present a friendlier human interface.

Database management is a necessity at Ames, not only for personnel records, but for just about every other task. For example, if one needed an updated list of all the IBM PC users at the Center or needed to keep a file of all the people in a certain program along with information on them, database management systems would do the job. The point is, as needs present themselves, a good database management system must be ready and qualified.

Probably the most important facet of the computer world in a large center like Ames is communication. Not all the computers at Ames are PCs. Communication with mainframes is supported mainly by asynchronous (ASYNC) and bisynchronous (BSC) communication, though there are many other ways. With these two different types of communication, IBMs can "talk" with, send and receive data to and from, and electronically mail information to virtually every other machine around the Center.

Bisynchronous communication provides 3270 emulation, allowing users to communicate with the IBM and IBM compatible mainframes. Here at Ames, the closed (personnel information) and open (programming) systems run bisynchronous protocol and are connected with IBM mainframes. With a BSC communication card in the PC, a user has access to the open and closed systems if he/she has an account on a system.

Asynchronous communication is available by adding an ASYNC communication card into the IBM PC. ASYNC is the vital link between almost all personal computers and terminals at the center. With the addition of the card, the user can work with the VAX and many other mainframes via the Micom Switching Network which provides linkup between machines and also gives general information regarding the whole network. Through the Network, access to the whole of Ames (and even the world) is given.

Over the years, trends in the computer industry have affected what systems, hardware, software, etc., NASA uses and in turn have initiated trends in the Ames computer world.

Thanks to capitalism and specifically, competition, the computer industry remains an area where the products keep improving and prices stay relatively low. Competition in the market also results in useful innovations. Recently, the market has made a movement toward more power for the user and more user friendliness. Regarding increasing power, recent trends have moved toward faster processors, smaller chip design, more memory storage, and (probably most important of all) networking. User friendliness is in high demand also since the computer is reaching users who need not or don't have time to become familiar with operating systems (e.g., the student, draftsman, architect, scientist, teacher, and other technical user). Recent advances have to do with ergonomic/human factors (e.g., terminals that are easy to read, comfortable keyboards with logical position of keys, etc.), windowing, and menu- and mouse-controlled workbenches that make the operating system seem almost nonexistent. As these two trends make work for the user much easier, offspring trends in the Ames environment have increased the productivity of employees.

Likewise for Ames, a movement toward two specific goals is taking place: (1) "dumb" terminals are "out" and "intelligent" workstations are "in," and (2) superior interactive capability must be provided for the user. A workstation is said to be "dumb" when there is no CPU present. For example, a VT100 terminal on a desk must be connected to a mainframe in order to function--there is no CPU present. The trend at Ames these days is moving toward a replacement of terminals with personal computers with at least asynchronous or bisynchronous communication cards that have all the power of a personal computer and still have access to mainframes. With these

"intelligent" workstations, employees can do more work faster on their PCs rather than compete for CPU time on a busy mainframe. Intelligent workstations also have an effect on another trend moving toward superior interactive capabilities for the users. This trend calls for a high-quality relationship as the user interacts with the computer. It requires that the computer has excellent response time and is easy to use. Like intelligent workstations, superior interactive capability saves time for the user and increases his/her computing power and productivity.

In the future, the IBM PC will have a greater role in the higher purpose of Ames and will continue to grow in power. Networking will have a large role in the increase of the IBM PC's significance at Ames.

As it is now, a user must go through a mainframe in order to communicate with other machines and other workstations. In the future, the mainframe, the "middle man," will eventually be eliminated and workstations will be able to communicate directly with each other as well as work directly with supercomputers like the Cray-2. With this new power, "traffic" over the mainframes will decrease greatly, allowing each individual user more time and more power. In addition, with the direct accessibility of the supercomputers, users will be able to submit their jobs to a computer that is much faster and much more powerful than the mainframes, and consequently, a very large amount of time will be saved by each user, and the quality of work will increase to a new high.

With such a bright future at Ames, the IBM PC is bound to remain at the Center for a long while. With the latest advances in graphics, word processing, database management, and communication, each individual at Ames will have more power at his/her fingertips as computer-interaction becomes less confusing. Competition and trends in the industry will continue to produce high-quality software and hardware, and the offspring trends at Ames will make workers more productive. "Ames applies the technology to increase worker productivity," writes Christine Falsetti. I think this is true and believe that the IBM PC will continue to be a significant and useful part of the goals and dreams at NASA Ames Research Center.

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## LOCAL AREA NETWORKING: AMES CENTERWIDE NETWORK

Edwin Price

### WHAT IS A COMPUTER NETWORK TO THE USER?

A computer network can benefit the user by making his/her work quicker and easier. A computer network is made up of seven different layers with the lowest being the hardware, the top being the user, and the middle being the software.

The base for computer networks is the hardware, which for Ames Centerwide local area network (LAN) is the Ethernet. The Ethernet in its simple form is a yellow coaxial cable which carries information from one computer to another. The next level up is the software. This is the level that allows the user to perform different functions by using protocols such as DECNET, TCP/IP, XNS, CHAOSNET, and 3SERVER. With these protocols the user is able to send or receive mail, perform remote logon, do file transfer, and do supercomputer job submission.

The first of these tasks, sending and receiving mail, gives the user the ability to talk to any other user on the same net or beyond. The next task, remote logon, gives the user the ability to logon to any other computer that is tapped into the same Ethernet. This function is useful when a user wants to utilize certain capabilities of another computer. File transfer is another option. File transfer is helpful when two people are working on a project and want to save it under one file, or if they want to see in what direction their partner's writing is going. The final task that the software performs is supercomputer job submission. This is used when a user wants to benefit from the abilities of a bigger and faster computer without leaving his/her own local computer.

The top level of this system is the user himself/herself. With all this help from his/her local terminal the user is able to do many different tasks without leaving his/her desk.

### ETHERNET

Ethernet consists of information passing through a yellow coaxial cable that runs through a building from one host (computer) to another. With the right software the Ethernet can be used to share information, or to gain access to another computer. The Ethernet carries the information between users in the form of packets. A packet is a series of on and off pulses which are divided into six segments: the preamble, the source (where the packet is being sent from), the destination (where the packet is being sent to), the type/length, the data or actual information being sent, and the CRC or amount of error. There is a limit in using Ethernet cable because the maximum distance the electronic signals can travel is 500 meters (1500 ft).

The Ethernet cable is only useful if a user can get information on and off the cable. In order to get the electronic signals off the Ethernet a person needs to tap into the cable with a transceiver. The two simplest ways of tapping into a cable are by using a vampire tap, or by using N connectors. Vampire taps are made by drilling a hole in the cable and placing into the cable a probe which picks up the electronic signal being sent. N-connector taps are made by cutting through the cable and placing N connectors on the ends, which then plug into both sides of the transceiver. Once a transceiver has been placed on the Ethernet, it becomes a translator by changing broadband signals traveling on the Ethernet into digital signals which go out on drop cables.

### REGIONAL ETHERNET

It is helpful to set up a stable regional Ethernet because it extends the range of an Ethernet segment from 500m to 2800m. It is also important to set up a regional Ethernet because the ideal state would be to have all computers communicating with each other. In order to set up a regional Ethernet the engineer must find a way to send information from one building to another. Due to the distance limitation of the Ethernet, one way to connect Ethernets in two separate buildings is by setting up a remote repeater link.

A remote repeater link is created in order to pass packets from one Ethernet segment to another. Here at NASA Ames the connection is made through fiber-optic cable. Fiber-optic cable is made up of tiny glass strands, 50 millionths of an inch thick. Four benefits of using fiber-optic cable are that it transmits low-powered light, it is not disturbed by outdoor factors, it is secure and does not decay due to weathering, and it has the ability to support more bandwidths than other cables.

Now that there are remote repeater links going from one building to other surrounding buildings, the central building has become a hub. A hub and its surrounding buildings take the form of a wheel with all the spokes meeting at a center building. Once a hub has been set up the next step is to connect it to an already existing hub. Connection can be made by another remote repeater link, but the problem with making this link is that remote repeaters have no filters. Information being sent from one building to another on the same hub gets sent over the link to the other hubs, congesting the whole network with unnecessary traffic. Another problem with remote repeater links is that they can only transmit up to 1000 meters between any two machines, and the distances between many buildings at Ames is much greater.

### APPLITEK BACKBONE

The Applitek Backbone can be used to solve both the traffic- and distance-limitation problems. Having a backbone connected to the network would almost be ideal because it puts gates at the entrance/exit of all hubs, but it still does not solve the problem of transmitting unwanted information throughout a single hub.

The gates the backbone uses are like checkpoints which check the packets for their destination. If the packet needs to be sent to another hub, Applitek checks it for destination and error. If the packet is correct the backbone transmits it. If the destination is local, then Applitek ignores it because the packet can be delivered by Ethernet.

The biggest benefit of using a backbone is that once it is connected, distance is not a factor. The backbone can transmit up to 30 miles on cable or by microwave. This concept opens up many possibilities. Not only is it easier to set up an efficient centerwide network, but the ultimate goal of having all computers communicating with each other, like the worldwide telephone system, is now in reach.

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## THE EFFECT OF SIMULATED WEIGHTLESSNESS ON PERFORMANCE AND MOOD

Bonnie Rosenberg

### OBJECTIVE

To study the effect of simulated weightlessness on the performance and mood of male bedrest subjects.

### BACKGROUND

The influence of the force of gravity of human biology was never investigated until the emergence of the space program. As the number of manned space flights increased, scientists were given a chance to research the body's response to zero gravity. They found that the major physiological changes included fluid shifts from the lower to the upper body and severe deconditioning of the heart caused by inactive muscles. With advancing technology space flights will become significantly longer in duration, and thus a need to counteract debilitating physiological changes is of great importance.

To better understand the effects of weightlessness on humans, researchers conduct bedrest studies to simulate zero gravity. It has been shown that a "head-down" tilt position or antiorthostatic hypokinesia is the best model to induce the adaptation period to weightlessness under laboratory conditions.<sup>1</sup> In this position a sense of disorientation occurs. As a result of immobility a loss of muscle tone ensues.

Past studies have shown that during the first two-to-three days of bedrest, subjects experience increased fatigue, lower mental work ability, decreased optical perception, and impaired sleep. These symptoms are most likely caused by an inverted position and the resulting fluid shifts. As bedrest continues the subjects become more fatigued, irritable, unable to concentrate, and experience increasing difficulty in sleeping. A careful study of performance parameters such as perception, reaction time, short term memory, vigilance, tracking, motor coordination, problem solving, and information processing, should determine performance efficiency.

### METHODOLOGY

At NASA Ames 12 healthy male subjects aged 32 to 42 were chosen to participate in this bedrest study. The subjects lived in a confined testing facility for a total of 42 days. This period was divided into 7 days of ambulatory pre-bedrest, 30 days of bedrest, and 5 days of ambulatory post-bedrest. During bedrest the subjects remained in a head-down ( $-6^{\circ}$ ) position for the 30 days.

Prior to pre-bedrest performance testing, each subject was given 10 trial performance tests. These tests were administered in order to familiarize the subjects with the test and to stabilize improvement on any given test. Careful study of each performance test battery has shown stabilization within seven trials.<sup>2</sup>

The performance test itself was administered on the Automated Portable Test (APT) System on a portable IEC computer. The test consists of a Visual Analog Scale (VAS) mood test and ten separate performance tests. The entire test required less than twenty minutes to complete.

The VAS mood test, added to the performance test, is an upgraded substitute for pencil and paper mood tests which tend to become dull and result in stereotypical responses. In this test a subject places a mark across a horizontal line corresponding to the strength of his particular feeling at that time. At each end of the line are two adjectives (usually antonyms). The VAS mood test adjectives are listed below:

#### MOOD STATE

Motivation  
Arousal State  
Tension Level  
Feeling  
Fatigue  
Ease of Concentration  
Physical Discomfort  
Feeling

#### TEST ADJECTIVES

Interested/Bored  
Alert/Sleepy  
Relaxed/Tense  
Happy/Sad  
Energetic/Weary  
Very Low/Very High  
Very Low/Very High  
Pleasant/Unpleasant

Following these displays are two sleep questions: "How much trouble did you have falling asleep last night?" (Not at all/Very much) and "How many times did you wake up last night?"

There are many advantages to a test such as this one. The test is easy for a subject to understand; it is quick to fill out; and it does not require much motivation. Also, the subject is not confined to answering in quantitative terms.<sup>3</sup>

The following is a description of each performance test.

The REACT 1 test measures simple reaction time between the presentation of a stimulus and the subject's response time. The subject is instructed to press a key when a box on the screen changes from a filled box to an outlined box. The subject is prompted by a short beep.

In the Code Substitution test a row of nine random letters is displayed at the top of the screen with an associated digit below each letter. When a row of scrambled letters appears below, the subject identifies the appropriate corresponding digit. This test rates cognitive and perceptual ability combined with visual search and perceptual speed.

A subject's spatial ability is tested in the pattern comparison portion of the performance test. The subject is shown two adjacent patterns of asterisks on the screen. He must determine whether the patterns are similar or different.

In the Sternberg Short Term Memory test the subject is presented with a target set of four digits which are flashed on the screen. Afterwards several four-digit sequences are displayed. The subject then indicates if any of the originally displayed digits are present in the new sequences. After a few sequences a new target set appears. This is a cognitive item recognition test and a vigilance test.

The next test is a video game called Air Combat Maneuvering (ACM). The subject is instructed to shoot at a moving "spacecraft" at the top of the screen. The missile launcher can be moved to the right or left. Points are accumulated by hitting the spacecraft. The score is not shown at the end of the game. It has been found that this video game is completely stabilized after the sixth trial.<sup>4</sup> This test measures two-dimensional pursuit tracking.

The subject is instructed to alternately tap two keys as rapidly as possible in the finger-tapping test. The test consists of three separate runs: two keys with the dominant hand, two keys with both hands, and two keys with the subdominant hand. This is a test of manual motor skill and dexterity.<sup>5</sup>

Cognitive reasoning, logic, and verbal ability are measured in the Grammatical Reasoning test. The subject reads a simple statement about the order of two letters, A and B, which are presented next to the statement. The subject responds if the sequence is true or false.

The last test is the Manikin Spatial Transformation test. A figure of a sailor is shown on the screen with a box below his feet and on each hand. A pattern (\*\* or 000) is in the box below his feet and matches one in his hands. The figure stands facing toward or away from the subject. The subject must determine which hand holds the matching pattern. The test measures a spatial ability to transform mental images.

## RESULTS

Only the change between pre-bedrest and bedrest can be analyzed because the experiment is still in progress. The results of the computed well-being score in the mood test and the score of the Air Combat Maneuvering were plotted as can be seen in figures 1 and 2.

For the mood parameter, day one represents the first day of bedrest. Day -6 is the beginning of the pre-bedrest period. As can be seen, the subjects' moods began low when they first entered the facility. Gradually their moods improved as they became accustomed to the new surroundings. On the first day of bedrest the moods of the subjects again went down.

For the performance aspect the results are strikingly different. The average score started out very low and gradually increased. This trend has continued through

the eighth day of bedrest. Unlike the mood parameter, the performance scores went up during the first day of bedrest.

## DISCUSSION

There have been many previous bedrest studies ranging up to 120 days in duration. In Soviet bedrest studies, subjects have shown increased fatigue and irritability, mood changes, memory loss, and difficulty in logical thinking.<sup>6</sup> Many subjects experienced a lack of motivation to perform even the most simple tasks.

Bedrest studies to research changes in sleep patterns during long periods of simulated weightlessness have been conducted.<sup>7</sup> In one particular study scientists found an increase in deep sleep. In other studies, difficulties in sleeping have been commonly observed. Many subjects could not fall asleep easily, slept for shorter periods of time, and woke up more often during the night. Sleeping disorders such as these began after the first two to three days of bedrest and occurred in up to 60% of the test subjects. It has also been found that head down bedrest as opposed to horizontal bedrest, magnifies these effects.

Conflicts exist in reported results of bedrest performance. In a 35-day bedrest study, reduced reaction time and performance of simple psychomotor tasks were found. However, other researchers have found little or no change in performance during bedrest. In another study some performance elements decreased while others remained the same.

There has been much speculation as to the contradictory results of these performance studies. There is evidence that performance decrements are more obvious in longer studies. Also, the type of performance test has an important role. Some tests are more sensitive to the effects of bedrest.

## CONCLUSION

The performance results of the bedrest study at Ames were not what were expected. The Air Combat Maneuvering performance test was tested to assure its reliability. However, the results from this study show a continued increase in performance. One would assume that scores would become constant if not decrease by the first days of bedrest because an inverted position would affect performance. It is also interesting to observe that while the subject's moods deteriorated, their performance improved.

Although the performance results were surprising, the mood results were as expected. At the beginning of pre-bedrest the subjects were nervous and therefore had lower moods than usual. Once accustomed to the facility, the subjects' moods improved. When bedrest started, the subjects were again nervous and uncomfortable so their low moods were reflected in the test. These mood fluctuations are very normal in experiments such as this one.

One can only wait to learn the final results of this bedrest study. However, there is still much more to learn about the effect of simulated weightlessness on performance and mood.

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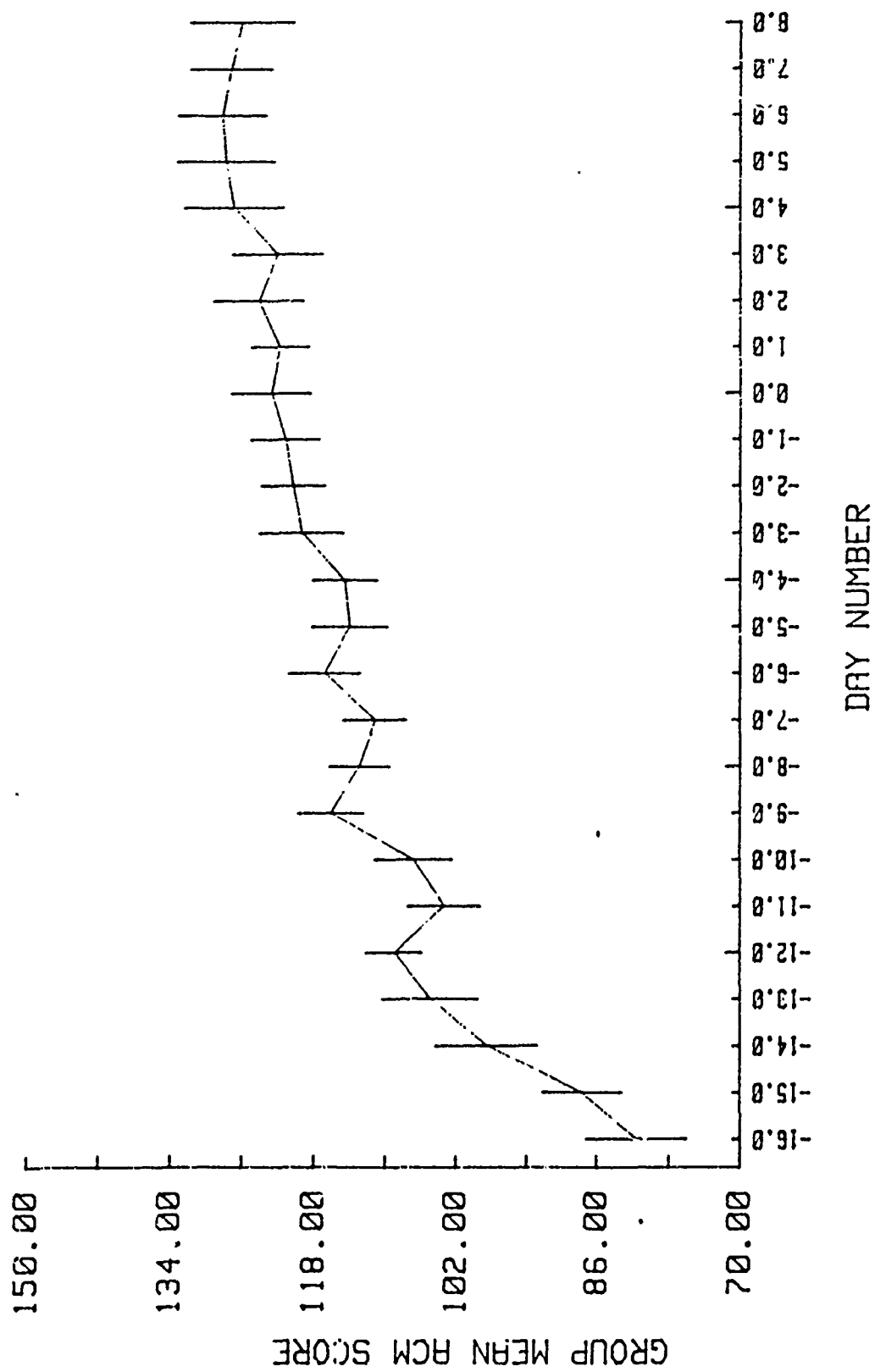


Figure 1.- ARC/JSC orientation, pre-bedrest, bedrest perf:ACM: group means.

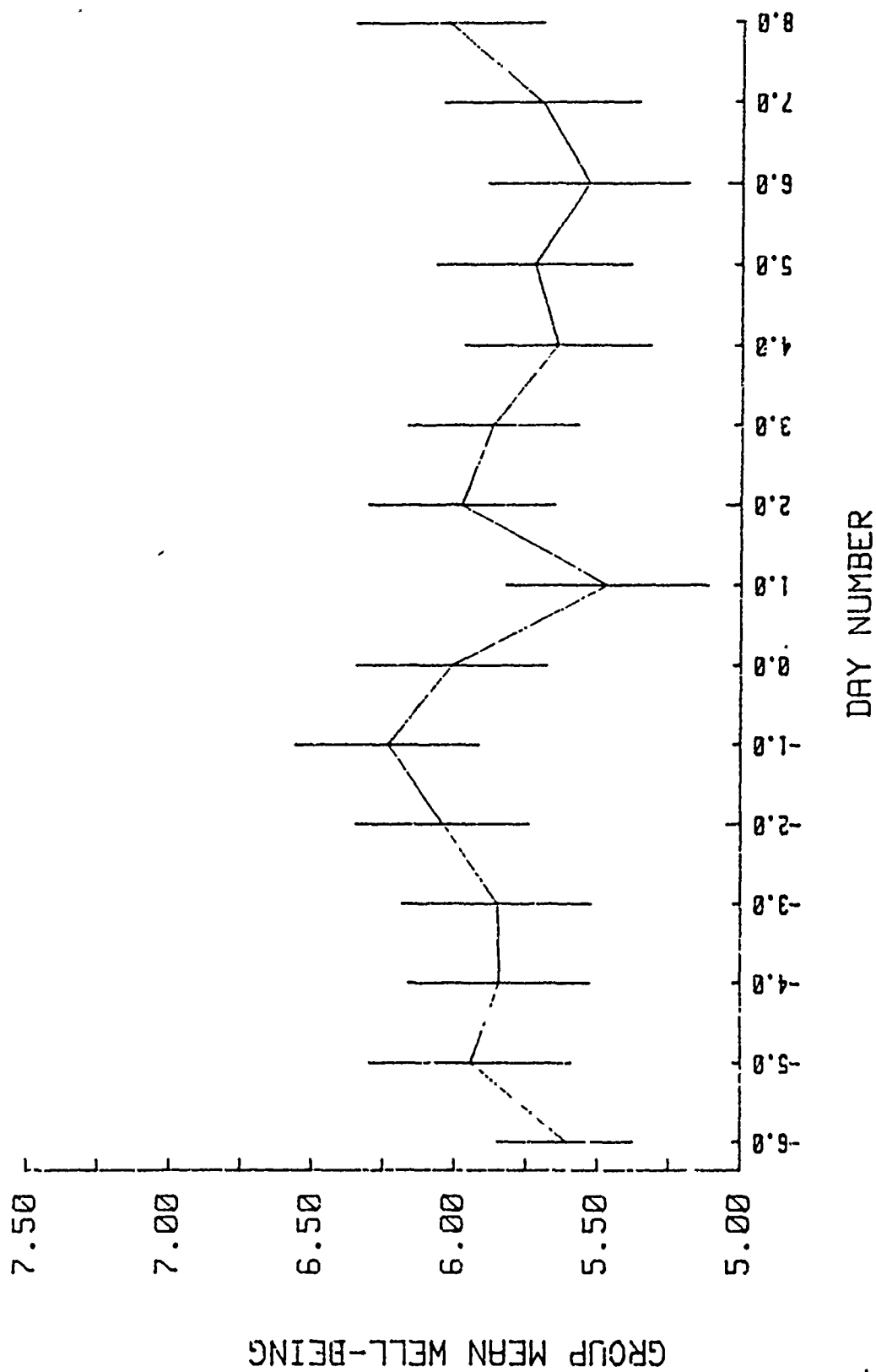


Figure 2.- ARC/JSC pre-bedrest and bedrest:mood:wellb.

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## THE APPLICATIONS OF COMPUTERS IN BIOLOGICAL RESEARCH

Jennifer Wei

Computers have assisted biological researchers, physicians, and lab technicians since the early 1950s. During the last twenty years computers have become an integral part of research, having acquired a broad range of applications which are useful in many types of research.

Data acquisition is useful in translating electrical signals directly into numerical values. These values are immediately stored in the computer, which also allows the user to go back at a later time to review data from a specific area or as a whole. When data are being taken, the computer continuously scans, identifies, and formats the input data. The computer may also be capable of rejecting irregular data and providing an indication of error. In addition, the computer may automatically calibrate each of the data sources at routine intervals.

Storage and retrieval programs are important assets of the computer because they allow the researcher to maintain a computerized filing system. With the immense quantities of condensed data being collected during even a single research project, a modern computer system is indispensable. During a study, the data can be entered and generated simultaneously. Similar to a manual filing system, the computer files may be kept for any length of time and updated at any time, but the paper files take up a lot of space, are time-consuming to establish, and are much less accessible than computer files.

To eliminate the time-consuming job of manually reducing raw data into readable data, the computer is able to perform the data reductions and transformations for the user. For instance, the results of an electroencephalogram are given as a series of electrical impulses. These impulses influence the stripchart pens, which in turn graphically present the raw data. These data are then reduced and processed by the computer into numerical values sufficient for further study. The computer is especially useful in reproducing images in computerized axial topography. Axial topography is a form of X-ray; however, it differs from the regular X-ray in that it sends the X-rays from head to foot rather than from front to back. The size and complexity of these transformations make it completely impractical to attempt manually.

Another obstacle many researchers previously faced was that of the mathematical computations and operations resulting from their studies. The modern computer can calculate many important physiological variables which may be calculated only indirectly through other variables. More importantly, calculations may be completed during a test or operation enabling the physician or scientist to continue with further tests. Some computers will also inform the operator if a measurement was improperly taken.

An important factor to a researcher is the computer's ability to recognize a pattern. When there have been a lot of data taken, it is important that the computer identify certain amplitudes and intervals. Very often the computer is programmed to

recognize only the most important peaks. In doing this, the researcher is saved days of scanning and analyzing a list of data that would normally take the computer a minute fraction of the time.

Similar to the pattern-recognition function is the process called limit detection. This process also serves to identify specific data; however, the identified data are irregularities rather than the general data a researcher would normally study. A pre-programmed range is designated as normal, and the scientist is warned of any abnormalities in the data. This program would be especially helpful, for example, in monitoring the data from an electrocardiogram or electroencephalogram being conducted along with several studies or even one other study. There would be more time for the researcher to observe other parts of the study and still be informed if something is wrong. In this case too, the data are stored in order to be used later.

Statistical analysis of data is also immensely time-consuming and tedious if attempted by hand. There is also a high risk where errors in calculation are concerned. When large quantities of data have been taken, the statistical analysis function is important not only because it saves the researcher from a lot of manual calculations, but also because it can scan the data itself and help the researcher or physician in finding similarities in the data, which could then lead to finding the cause of an unusual set of data. Statistical analysis by the computer is important even in simple descriptive statistics such as means, standard deviations, and frequency distributions.

One of the more important factors in data analysis, acquisition, processing, etc., is obviously the variety of ways in which it can be presented. There are several different forms which are applicable in most situations such as table printouts, charts, plots, and cathode-ray-tube displays. There are also some programs which sort and organize the data before presenting it in the graph or chart form. Graphs are useful if there is a lot of data that need to be observed in general form; table printouts are useful to the scientist as a quick reference; the charts are helpful for presentation at a meeting or to a boss or supervisor.

A very important asset of modern computers is their ability, when programmed to do so, to actually control the functions of certain laboratory measurement devices. At the same time, they collect and store data from these sources. This is important because it reduces the need to have a crowded operating room or laboratory full of technicians. The scientists are able to concentrate on the actual patient without the added distraction of manually controlling all of the equipment. With these control functions, the computer can also provide feedback to the source of its data. There are programs that regulate the rate, quantity, and/or the concentration of reagents added to a process. A computer can also control the temperature of a temperature bath. It can be programmed to recognize certain results that would indicate possible error. When this occurs, it also has the capability of automatically compensating for some of those sources of error. For more serious errors, the computer would automatically call the error to the operator's attention.

Research in many fields could not be done without computers. There is often a great deal of technical data, even in the biological fields, that need to be analyzed. These data, unfortunately, previously absorbed much of every researcher's time. Now,

due to the steady increase in computer technology, biological research scientists are able to make incredible advances in their work without the added worries of tedious and difficult tasks such as the many mathematical calculations involved in today's research and health care.

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## ANIMALS IN SPACE

Angela White

Animals have always been important to the space program. The United States flew monkeys in rockets between 1948 and 1952, ten years before the first orbit of the Earth by a man. The Soviet Union used dogs in their space program--a Soviet dog orbited the Earth in Sputnik II for a week in 1957. Monkeys were tested in the early years of NASA to determine whether it was safe for humans to fly into space. After Yuri Gagarin of the USSR became the first man to orbit the Earth, space animals were all but dropped in favor of using humans. However, recently, more animals are going into space, mainly for research purposes. On Spacelab 3 (SL-3), 26 animals experienced weightlessness and were studied thoroughly afterward, yielding valuable data. Animals are a valuable part of the space program and NASA should support sending more animals in the future.

The history of animals in space is not nearly complete. Such a history would show how well animals have been treated in the space program. Certain activist groups have advocated the total elimination of animal use in research, including space research, because of reports of inhumanity in too many research laboratories. A ban on animal use in research would decrease the number of animals killed and tortured each year in the nation. Such a ban, however, would severely cripple the space program. So far, NASA has an excellent record of humane treatment of animals. For example, 24 rats and two squirrel monkeys were part of the last Spacelab mission, SL-3. Originally, the animals were sent only as a test of the research animal holding facility, or RAHF (fig. 1).

Fortunately, the mission produced much more useful data than expected. It was discovered that the cage was an acceptable, nonstressful environment. One indication that the RAHFs were nonstressful environments was the growth rate of the rats. Mission rats grew slightly less than rats in similar housing on the ground, and those rats grew less than rats in vivarium cages. However, according to Christopher Schatte, project scientist of the SL-3 life sciences payload, weight loss was probably caused by reduced energy requirements owing to microgravity, and also adaptation to a new environment. Another indication of low stress levels was the fact that the weights of certain organs, such as the spleen, brain, and heart, were within normal limits of variation. Other indications of chronic stress, such as adrenal hypertrophy and liver atrophy were not observed.

The monkeys were not analyzed postflight as thoroughly as the rats were, so data on life processes are not available for them. However, it was shown that squirrel monkeys will probably be acceptable in studies of space-adaptation syndrome, or space sickness. One monkey maintained normal eating behavior, but one showed decreased food intake during the first four days of the mission, then returned to normal eating behavior in the last three days. Videotape records of behavior showed decreased activity, followed by normal activity. Although no actual sickness was observed, these results are consistent with symptoms of sickness in monkeys centrifuged at 1.5 g (1.5 times normal gravity) and with human space sickness. No post-

flight abnormalities were observed. It is hoped that the squirrel monkey will be a good model for future studies.

Although space research has been humane, some people are concerned about the necessity of animal research. If it is not absolutely necessary, then it should not be conducted. Animals are necessary to the space program and have been from the beginning of the program. Some experiments are performed on animals that could not be performed on humans.

The rats on SL-3 are an example of vital studies possible only on animals. In order for the researchers to obtain data, the rats were sacrificed as soon as was possible after landing. (There was a 12-hr gap between landing and sacrifice, due to a late change in landing site.) The detailed studies made of conditions such as bone and muscle loss would not be possible on humans.

Future payloads of animals will be necessary in order to provide answers not available from human studies. Spacelab 4, renamed Spacelab Life Sciences 1 (SLS-1), will carry the newly modified RAHF. (The RAHF was redesigned after it allowed particulates to escape on SL-3.) The RAHF will carry no animals, but will be tested to see if it allows particles to escape. SLS-1 will also carry jellyfish for observations not possible on mammals, such as graviceptor formation, graviceptor function, and swimming abilities. Graviceptors of jellyfish are easily observable, unlike those of humans. Studies of graviceptors and swimming behavior could give clues as to how graviceptors work in humans. Rats will go up on SLS-1; not in the RAHF, but in the animal enclosure module, or AEM (fig. 2). It is bigger than a single RAHF unit and holds five rats in the same area, or ten rats total in two areas. It has gone up on two previous missions and hopefully will go up on several others. Catheters attached to blood vessels near the heart in the rats will provide blood-flow data difficult, if not impossible, to obtain in humans. The rats will also be sacrificed postflight.

On a future Spacelab mission, Spacelab Japan (SL-J), frog embryos will be fertilized in space in the frog embryology unit (FEU--fig. 3). Knowledge of embryology in space has potential applications in future projects, especially the Space Station. However, until the station is built, studies of embryology must be limited to animal embryos that develop quickly, which is necessary in a seven-to-ten-day shuttle flight. The rapid development of frog embryos makes this experiment possible, which would be impossible with humans.

No matter how humane animal experiments are or how much data can be obtained which are unavailable from humans, all animal experiments would be useless if their results were not applicable to humans in useful ways. Nonhuman (animal) life processes are appropriate models for human life processes, and useful data can be obtained from them. As indicated above, on the next Spacelab mission, SLS-1, rats and jellyfish will be part of the payload. The jellyfish are included in order to study their graviceptors and methods of swimming in space. This is applicable to humans because of the lack of information we have on human graviceptors. If the mechanism of jellyfish graviceptors is studied, it might provide some clues to human graviceptors and how they work.

The rats will be monitored internally by implants in a flap in their backs. (The rats show no evidence of noticing these after about one day.) Information from the monitoring, such as blood flow, blood chemistry and rate of metabolism will provide more clues as to how the human body adapts to space, in good ways as well as bad. Postflight dissection will yield information on the inner ear, bone, bone marrow, spleen, muscles, and blood. Even the frogs on SL-J will provide embryology information that will be applicable to humans. Stages of development in frog embryos which are gravity-sensitive will be examined and analyzed. The data will then be compared with current knowledge of human embryos. Future flights such as these will provide much useful data.

SL-3 has already produced results and data from the rat and monkey experiments, most of which will be applicable to humans, but some of which will have to be interpreted before being of use. The decrease in production of gamma interferon by spleen cells cultured postflight is one of several changes that were previously linked to stress and are now linked to the microgravity environment. This particular change has not been explained and may be, like the other hematology, immunology, and blood chemistry results, invalid, since they would be most susceptible to the 12-hr gap between landing and sample acquisition.

However, there are some results that are valid and can be explained only by speculation at this time. ("Speculations" made here are mainly those of Christopher Schatte (1986).) The overall heart rate of the rats decreased slightly from preflight measurements, although it was steady. This probably comes from the reduced activity of the rats. A more important observation was the fact that body temperature rhythms disassociated from cardiac rhythms and began to free run. When these two rhythms disassociate, it can produce adverse effects, such as jet lag. Further experiments will be needed to test rhythm disassociation and determine its effects.

Other areas where the rats showed changes possibly applicable to humans were muscles, bones, and growth hormone production. "Growth" hormone is involved in maintenance of muscles and bones, which showed deterioration. Flight animals produced less growth hormone than controls. This reduction could have caused the deterioration in muscles and bones. If this is true in humans, hormone therapy and exercise might counteract those effects. Loss of mass in muscles was evident, especially in anti-gravity muscles. There were two groups of rats--mature rats and immature, growing rats. The immature rats lost less muscle mass, but since they were supposed to be growing, there was a greater difference in weight between the flight and control immature rats than between the flight and control mature ones. Loss of mass tended to occur because of cell shrinkage rather than self-destruction. This could explain why no apparent long-term damage has been observed in humans. The main changes in bone were not in mass; they were increased fragility, reduced bone-plate growth activity, and shifting of bone mineral from lower to higher specific gravity fractions. Increased bone demineralization, usually considered an indicator of decreased bone integrity, did not occur in significant amounts. This integrity indicator may have to be reassessed, since an increase in bone fragility did occur. A decrease in a certain polypeptide (osteocalcin) might be responsible, since decreases correlated with mineral loss. If it is, therapy might be possible. The little demineralization that did occur was found even in bones that did not play a significant anti-gravity role. This indicates

that a systemic factor might be involved. There is much to be learned from SL-3, if we can discover what the results mean. However, the results that we do understand are probably applicable to humans.

Animals are indispensable to the space program. Their continued use could have many significant results. Those who are opposed to using animals in space should remember that space animals are treated humanely; they are necessary because results can be obtained from them that would be unobtainable from humans; and results from animal experiments can be applied to human systems. Therefore, NASA should continue to use animals in space research.

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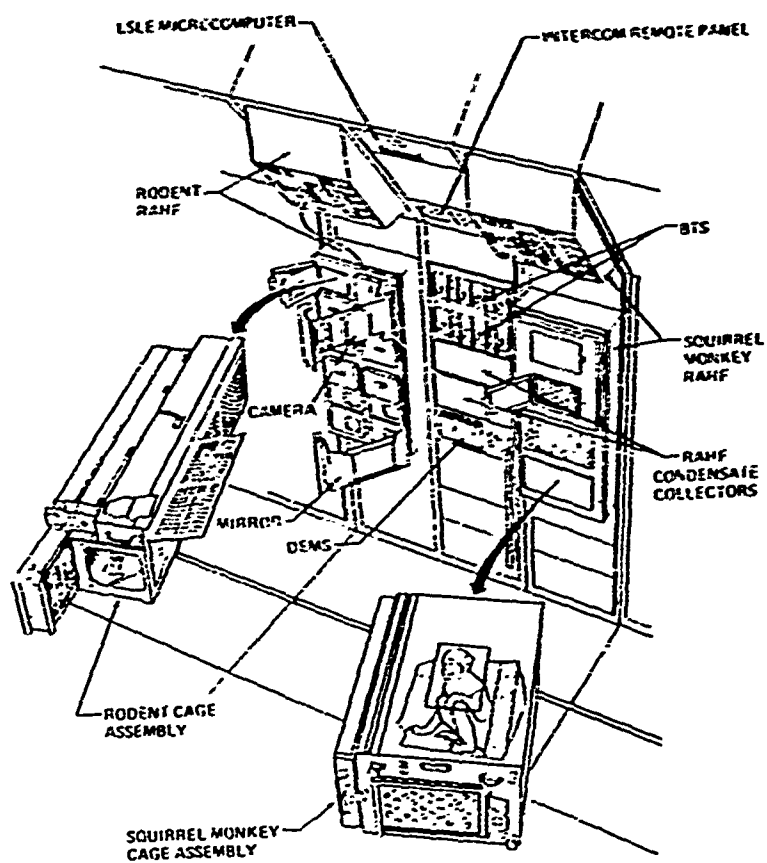


Figure 1.- The research animal holding facility (RAHF).

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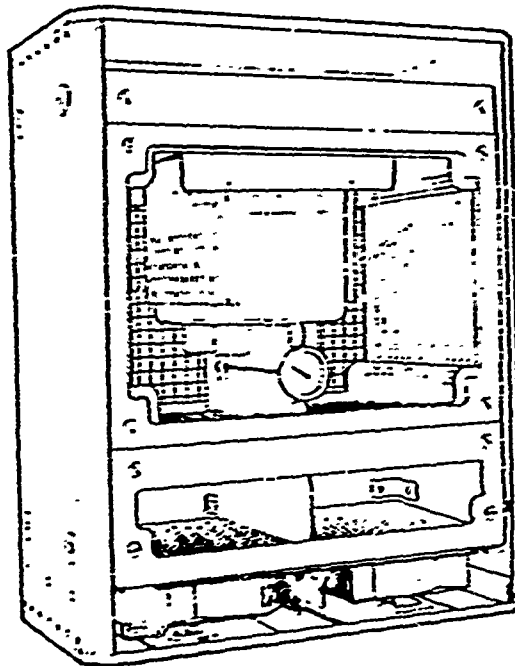


Figure 2.- Animal enclosure module.

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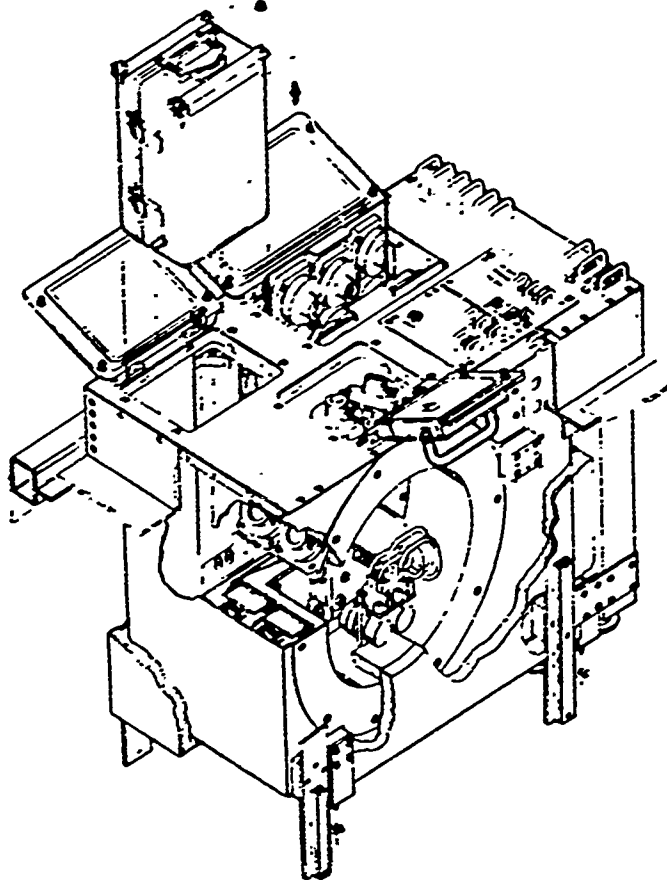


Figure 3.- Frog embryology unit.



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16. Abstract <p>Engineering enrollments are rising in universities; however, the graduate engineer shortage continues. Particularly, women and minorities will be underrepresented for years to come. As one means of solving this shortage, Federal agencies facing future scientific and technological challenges were asked to participate in the <u>Summer High School Apprenticeship Research Program (SHARP)</u>. This program was created seven years ago to provide an engineering experience for gifted female and minority high school students at an age when they could still make career and education decisions.</p> <p>The SHARP program is designed for high school juniors (women and minorities) who are U. S. citizens, are 16 years old, and who have unusually high promise in <u>mathematics</u> and science through outstanding academic performance in high school. Students who are accepted into this summer program will earn as they learn by working eight hours a day in a five-day work week. This work-study program features weekly field trips, lectures and written reports, and job experience related to the student's career interests.</p>					
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